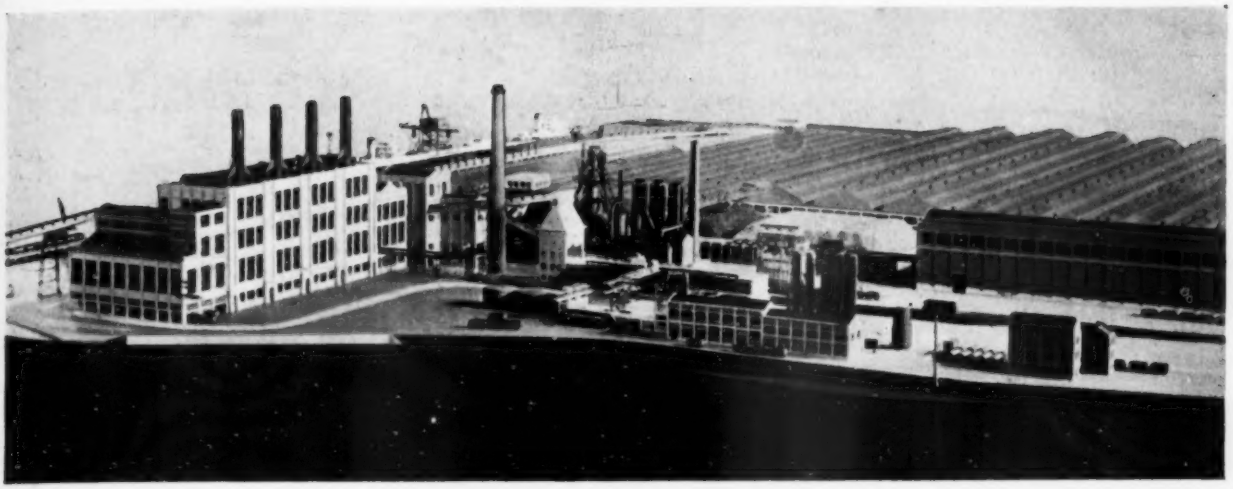

A Photograph Showing the Extent of the Works when Completed.

Progress of the Ford Works at Dagenham

ALTHOUGH it is little more than a year ago that a commencement was made to build the new Ford works at Dagenham, the changes made on what was originally a wide stretch of marshy land are remarkable. These works are being erected on an estate of 500 acres, of which the industrial developments involve 276 acres, whilst 100 acres are being reserved for future extensions of the plant. The works proper are being built on an area of 110 acres, having a frontage of 2,400 ft. on the Thames.

Progress in the construction of the various buildings has been rapid; already the majority of the machine shops, assembly shops, and foundry are nearing completion, and in a comparatively short time they will be ready for the installation of modern machinery. The construction work that can be seen is indicative of the immense progress made, but the preparatory work necessary before any attempt could be made to erect buildings emphasises the enormous amount of work that has really been accomplished. The marshy character of the land necessitated considerable reinforcement, whilst, in addition, roads had to be made, bridges built, railways laid, and wells sunk. One of the biggest tasks consisted in piling the ground to support the tremendous weight of plant to be erected, and over 11,000 of these piles have been driven, some of which are over 80 ft. long. On sections which are to carry the power-house, the blast-furnace plant, and in parts of the shops where heavy machines are to be erected, the piles have been driven so closely that the foundations almost comprise solid reinforced concrete. The vital necessity of these preparations is apparent when it is realised that with the blast-furnace plant alone a load of over 5,000 tons is imposed on a comparatively small area. About two miles of railways have been laid, one and a half miles of drainage work completed, and about a mile of roadways formed on embankments. In addition, dredging has been in progress along the river frontage in preparation for the construction of a jetty now being erected. This jetty is to be 1,800 ft. long and 51 ft. wide, with a floating pontoon at the western end for handling passenger traffic, to be dealt with at all times of the tide. The western part, for about 600 ft., is intended for the outward shipment of goods, and will accommodate two 6,000-ton vessels, with an average depth of water of 20 ft. The central part is reserved for the accommodation of vessels bringing coal, ore, and limestone for the blast furnace. This has now been dredged, and will accommodate vessels up to 12,000 tons, with an average depth of water of 28 ft. On the steel superstructure extending to the land will be carried two lake type unloaders, each having an output of 600 tons per hour. The eastern part of the jetty, approximately 600 ft., is intended for handling refuse to be delivered to the power-house by conveyors leading, first from the jetty on the transfer station, and, second, from the transfer station to bunkers on top of the power-house. Arrangements are being made to accommodate up to six 200-ton refuse barges at the same time. The whole wharf will be provided with the most modern electrical transporting facilities.

A brief reference to the various buildings that will comprise these immense works will give some indication of the size of each department, and also some idea of the general layout. The building to house the higher executives is situated in the centre of the frontage. It will be 200 ft. long by 50 ft. wide, and the space between this office and the first production building—a width of 40 ft.—is reserved for a garage.

The foundry and machine-shop is 1,260 ft. long and 300 ft. wide. The western part will include the employment offices, and the eastern part will represent the foundry proper, and the hot-metal house. Running parallel with the foundry are the manufacturing and assembly buildings, separated from each other by covered railway courts, each 80 ft. wide and carrying two sets of tracks. Both the manufacturing and assembly buildings are 1,000 ft. long and 300 ft. wide, the latter comprising seven bays, with a height of 14 ft. to the eaves. This building is intended for the assembly of finished cars, and also for spare car parts. The heights of the manufacturing and foundry buildings are 30 ft. to the eaves, with the exception of the eastern section of the foundry, which is 70 ft. Each of the manufacturing bays will be provided with a 10-ton crane, 87 ft. in span, whilst each of the railway courts will be provided with a 10-ton crane, with a span of 77 ft.

The ore yard has been designed to store an unusual supply of raw material. It is being divided to give separate storage for coal, ore, and limestone, the capacity of the respective bins being 34,200 tons of coal, 122,000 tons of ore, and 11,500 tons of limestone. The material in these bins will be handled by an ore bridge operated electrically.

The blast furnace, which is being built by Messrs. Ashmore, Benson, Pease and Company, is of Freyn design, and will

have a nominal capacity of 500 tons per 24 hours. The plant includes three Strack stoves and cast-house; near to the blast-furnace plant, and to the south of it, special arrangements are being made for the installation of a Dorr thickener for reclaiming the iron-ore dust produced in the plant. This will be the first installation of its kind in this country, and is intended for the production of sinter material to be used in the blast furnace. Although the application of sintering processes for agglomerating fine ores, as well as flue dust, is not by any means new, it is increasing. These processes are giving satisfactory results, and ores are now being used which formerly presented many difficulties. Sintering has the effect of reducing the sulphur contents of a material very considerably, and it has proved an attractive method of utilising materials which were unworkable because of their sulphur content. The mechanical means by which sintering is accomplished differ considerably, and many types of machines have been developed.

The production of the blast-furnace coke will be effected by the installation of a battery of 45 ovens of Wilputte design, now being built by Messrs. Coppee Company. These are designed for carbonising 800 tons of coal per 24 hours. In view of the loss of heat involved in the usual quenching methods considerable attention has been directed to the possibilities of avoiding the use of water, and in order to conserve the heat. For this purpose the system of dry quenching has been developed, and this form of installation will be erected in these works in order that the heat from the incandescent coke from the coke ovens will generate steam. This dry-quenching plant is being designed to generate 15,000 lb. of steam per hour, to be used chiefly in connection with process work.

The power-house will include three high-pressure boilers, and arrangements are being made for future extensions and the installation of another boiler. Each of these boilers will have an evaporation capacity of 200,000 lb. of steam per hour, and run at a pressure of 1,200 lb. per square inch. They are designed to burn refuse, blast-furnace gas, coke-oven gas, or pulverised fuel, and are being built by Messrs. Babcock and Wilcox. In addition, two low-pressure boilers, each of 200 lb. pressure, with room for a third, are to be erected for process work generally. A refuse-preparation house, at one end of the power-house, is being erected for treating up to 1,000 tons of refuse per day. It is being equipped with machinery designed to separate the material according to size and type, including iron, steel, and tin-plate. Advantage is being taken of the high efficiency of the turbo-alternator for generating power from the high-pressure steam, and a B.T H turbo-alternator will be installed giving a 30,000 k.w. output in three stages. This is designed to run at 3,000 r.p.m. The engine-room will include the plant for two blowers for the blast furnace. From the power-house, and connecting to each of the three main shops, is a tunnel 1,060 ft. long, 12 ft. 6 in. wide by 8 ft. 6 in. high. Supplies of gas, water, compressed air, steam, and electricity are to be conveyed through this tunnel to every part of the works.

Adjacent to the power-house a coal and coke-handling plant is being installed, for the purpose of selecting and

(*Continued on page* 139.)

General View of the Shops.

An Inside Illustration of one of the Shops.

The Testing of Cast Iron.

By J. W. Donaldson, D.Sc.

Modern engineering practice and developments have made new demands on cast iron. Factors other than strength, such as resistance to heat, shock and wear, have to be considered.

THE continual new demands that are being made for materials of construction capable of meeting more and more severe conditions of service have resulted in a large increase in the number of tests through which samples of these materials have to pass. The question of tests and testing has aroused a considerable amount of discussion, particularly when applied to cast materials, ferrous and non-ferrous. Steels which have been rolled or forged are usually fairly homogeneous materials, but the same cannot be said of castings which are rarely, if ever, even approximately homogeneous. To correlate results obtained from test pieces with castings of various designs and thicknesses has been a problem to founders and metallurgists, and is still one which requires a large amount of investigation. A fair amount of work has been done, however, and for certain non-ferrous alloys and simple types of castings satisfactory results have been obtained. With grey cast iron investigation has been more difficult, owing to the peculiar nature and complexities of this alloy.

Modern engineering practice and the development of the internal-combustion engine have made new demands on cast iron. It is being used for parts where other factors than strength have to be considered—factors such as resistance to heat, shock, and wear. There is also a marked tendency to cut down weight, and consequently the reduction of scantlings can only be accomplished if test results indicate that material as more reliable. Not only has it been necessary to investigate and reinforce the usual tensile, transverse, and compression tests, but additional tests such as hardness, impact, fatigue, and shear tests have had to be considered. A review of these various tests and the various methods of testing will indicate the more recent developments which have taken place.

Methods of Testing.

In the testing of all cast materials, and particularly in the testing of grey cast iron, the methods of testing are important. First, there is the type of test bar to be used, so that results are obtained that can be relied upon to give data comparable, as far as possible, with the properties of the casting; and secondly, whether the test bar is to be cast on the casting or cast separately from it. On this last point there is a considerable difference of opinion. It is generally accepted that the casting of small test bars on large castings, or separate from them, and testing them to a specification of 11 tons per sq. in. tensile and 2400 lb. transverse is of little use, and the results obtained are not representative of the casting. A small test bar attached to a large casting will be affected considerably by the cooling of the large mass of the casting, and the structure and properties obtained will be in most cases very different from the structure and properties of the casting. Small test bars cast from the same ladle into the same mould, but not attached to the casting, must also, on cooling, have different properties. It has been suggested that better results are obtained by having as a test bar an extension piece of some part of the casting, or by cutting a piece from the casting head, and there is much to be said for such procedure where it is possible to do so.

The whole problem is a difficult one and has given rise to many investigations. A mixed Committee of the British Cast Iron Research Association and the Institute of British Foundrymen, appointed in 1923, considered the whole question, and their recommendations for the testing of grey cast iron were adopted with certain modifications by the British Engineers' Standards Association, and issued in the B.E.S.A. Specification No. 321, 1928. In this specification the size of test bar is varied with the thickness of the casting (Table 1). For castings over 2 in. in thickness a 2·2-in. bar is required, and for castings below ¾-in. thickness a 0·875-in. bar. Castings with thicknesses between ¾ in. and 2 in. are represented by a 1·2-in. test bar. These test bars are to be cast at the same time in the same mould from the same ladle, and may, or may not, be attached to the casting, the engineer or user

TABLE 1.

SUMMARY OF TRANSVERSE AND TENSILE DATA FROM B.E.S.A. SPECIFICATION NO. 321 FOR GREY IRON CASTINGS GRADES, A AND C.

Size of Casting.	Test Bar.			Transverse Test.					Tensile Test.			Transverse Rupture Stress.	
	Diameter of Test Bar.	Actual Size as Cast.		Distance Between Supports.	Grade A.		Grade C.		Machined Diameter of Bar.	Minimum Breaking Stress.		Bearing Stress.	
		Diameter.	Length.		Minim'm Load.	Minim'm Deflection	Minim'm Load.	Minim'm Deflection		Grade A.	Grade C.	Grade A.	Grade C.
	In.	In.	In.	In.	Lb.	In.	Lb.	In.	In.	Tons per Sq. In.	Tons per Sq. In.	Tons per Sq. In.	Tons per Sq. In.
Under ¾ in.	0·875	0·975 0·925 0·875 0·825 0·775	15	12	1620 1390 1185 1000 835	0·12	1315 1130 960 810 675	0·10	0·564	12	10	24·1	19·6
¾ to 2 in.	1·20	1·30 1·25 1·20 1·15 1·10	21	18	2445 2190 1950 1730 1525	0·15	2010 1800 1600 1415 1245	0·12	0·798	11	9	23·1	18·9
Over 2 in.	2·20	2·30 2·25 2·20 2·15 2·10	21	18	11200 10600 10000 9425 8870	0·12	10130 9535 8950 8390 7855	0·10	1·785	10	9	192	17·2

having the option to say which method he prefers. The specification refers to certain grades of iron which are of a general nature, but so far as sizes of test bars are concerned it can be adapted to all grades, including high-class irons.

Transverse Testing.

The transverse test on cast iron is usually carried out at present on square or rectangular bars 2 in. × 1 in., or 1 in. square, tested on centres 36 in. or 12 in. apart. Such bars are usually tested without machining, and the result expressed as the actual breaking load irrespective of the actual section. This method of testing and of expressing the test result is to be condemned. Very few bars are cast accurately to size, and it is not generally realised that $\frac{1}{16}$ in. over or under size on a 1-in. square bar gives an error in area, using the formula $D^2 \times B$, of approximately ± 18%.

Pearce[1] has shown that round bars invariably give better results than square bars of similar size, and the round bar has been adopted in the B.E.S.A. Specification. Such bars are to be tested without machining provided the diameter does not exceed 0·10 in., otherwise they are to be machined to the specified dimensions (Table 1). The small bar, 0·875 in. diameter, is to be tested on 12-in. centres, and the larger bars on 18-in. centres. For each size of bar a minimum breaking load and a minimum deflection require to be specified, such values being varied for the grade of iron castings tested.

A bar of grey cast iron cast in a small section is stronger than a bar of the same iron cast from the same ladle at the same time in a larger section. For comparison, therefore, of the strength in bars of different sectional area, and consequently in different sections of a casting, it is necessary to calculate from the results obtained the modulus of rupture or the transverse rupture stress. This is done from the bar formula $f \frac{W.L.^3}{0{\cdot}4d}$ where L is the distance between the supports and d the diameter. Results obtained from this formula are not strictly correct as cast iron is not an elastic material, but are sufficiently accurate to give a comparison of the strength of different sections of a casting. For the grades of cast iron A and C, given in the B.E.S.A. Specification, the transverse-rupture stress varies from 24·1 to 19·2 tons per sq. in., and 19·6 to 17·2 tons per sq. in., respectively, for sections of 0·875 to 2·2 in. diameter (Table 1).

In France specifications for cast iron include, among other physical tests, a transverse test. Unlike the British method of testing, test pieces are not cast on the casting or cast separately, but are taken from the casting by trepanning small pieces. The transverse test is carried out on a bar 8 mm. by 10 mm. and 35 mm. long, tested on centres 30 mm. apart. The advantages claimed for this method of testing are economy, rapidity, simplicity, and precision, and that it can be used in routine work without difficulty. The method of carrying out this test and the results obtained are given in a paper by Thomas and Bois[2], read at the International Foundrymen's Conference in London last year. Many objections are raised to this method of testing, the principle being that small test pieces taken from a casting while suitable for experimental work are not suitable for commercial testing, and there are no definite evidences that test results so obtained represent the properties of the casting. These objections are dealt with by the authors in their paper, but the paper itself gave rise to a considerable amount of controversial discussion.

Tensile Testing.

The tensile test of grey cast iron is one which has to be carried out with extreme accuracy if satisfactory results are to be obtained. Cast iron is not a ductile material, and its elastic properties are low. Test bars in the testing machine have to be in true alignment and loading has to be uniform, otherwise erratic results may be obtained from bars of the same material cast at the same time. There is no doubt that the transverse test as a routine test is more satisfactory and less expensive, although many engineers and designers still specify and use the tensile test.

In the B.E.S.A. Specification tensile tests are specified to be carried out on the three sizes of test bars with these bars machined to 0·564 in. for the small bar, 0·798 in. for the medium bar, and 1·785 in. for the large bar (Table 1). Machining the test bars involves breaking the skin and sacrificing the skin strength, and at the same time there is a diminution in strength due to the reduction in section. To obtain a relationship, therefore, between tensile and transverse tests on bars cast a similar size, is difficult. It has been shown by Pearce[3], however, from test results that for the engineering irons given in the B.E.S.A. Specification the ratio of transverse rupture stress to tensile stress varies from 1·8 to 2. For commoner grades of irons, due to the tensile strength falling more rapidly than the transverse strength, the ratio increases, and for high-grade irons where the tensile strength increases to a larger degree than the transverse strength the ratio is lower. According to the same investigator the maximum range of variation for sound bars is 1·65 to 2·25.

Compression Tests.

Cast iron is considerably stronger when tested in compression than in tension. A cast iron which has a tensile strength of 10 to 12 tons per sq. in. will withstand compressive stress to about five times those values. Recent investigations, however, have shown that as the tensile strength increases the compressive strength does not increase at the same rate. Modern high-grade irons with tensile strengths of 18 to 22 tons per sq. in. have compressive strengths about 70 to 80 tons, so that the ratio of compressive to tensile strength has to be reduced to 3·5 to 4 (Table 2).

TABLE 2.

TENSILE AND COMPRESSION TESTS.

Tensile Strength. Tons per Sq. In.	Compressive Strength. Tons per Sq. In.	Ratio *Tensile.* Compression.
9·5	44·5	4·7
11·2	52·0	4·65
15·0	61·8	4·1
18·3	68·7	3·8
23·3	85·4	3·65

Shear Tests.

The shear test as a commercial test for cast iron has been considered by many foundrymen, principally in Britain, France, and America. In the paper by Thomas and Bois[2] it is recommended as the most suitable test for cast iron. It is suggested that the test should be taken on test bars trepanned either from a casting or from a cast-on boss. From such test pieces small cylindrical test pieces, 20 mm. × 5·64 mm. diameter, are prepared, and these are tested to give an average strength of at least 25 kilogs. per sq. mm.

Opinion in this country as the result of the work of various investigators is against this type of shear test as a commercial test. A 0·564 mm. (0·22 in.) diameter test bar is considered too small to yield satisfactory results, being too sensitive to changes in the structure of the material. An increase in the size of the test bar gives an increase in the shear stress value; Pearce[4] finding the strength to increase 4 tons per sq. in. by increasing the 0·22-in. bar to 0·5 in. diameter, three tests being made at each size from the same bar and position. According to results given by Jolley[5], to obtain accurate results, trepanned test pieces require to be machined or ground to dead size. Shaw[6] has also pointed out that to obtain

similar readings, even from the same sample, the testing machine would require to be standardised, and that the slightest wear affects the results.

These opinions are supported in the American Exchange Paper to the International Foundrymen's Conference last year by Bolton[7], who considers the work of Elliot and of Rother, and also his own work on shear testing, and states that the test proposed by the French foundrymen, although good in its basic idea, is hardly precise enough for use in a commercial specification. The testing machine is not sufficiently rigid, and the method of preparing test pieces is open to criticism. Accurately machined test bars are a necessity, and the test piece proposed is small to be representative of the general properties of the iron. These contentions support those of the British investigators in condemning the shear test as a commercial test. Bolton states, however, that with certain modifications it is useful in research work.

The relation of shear strength to tensile and transverse strength has also been considered very fully by Shaw, who shows from published results that the ratio shear stress to tensile stress varies from 0·76 to 2·3, and shear stress to transverse stress from 0·51 to 1·83. He also points out that the shear tensile ratio invariably increases due to lower tensile results, and considers therefore that when the shear test is compared with either tensile or transverse results, an artificial value is given to the shear test.

Fatigue Tests.

During recent years a considerable amount of work has been carried out on the fatigue testing of materials. The larger proportion of this work has been devoted to steels, both plain carbon and alloy, and has resulted in the determination of the fact that the fatigue stress of steels is approximately 45 to 50% of their ultimate tensile strength. The extended application of cast iron in engineering practice, and its use in parts subjected to rapid reversals of stress, have led to similar investigations on this alloy.

Experiments carried out by Bulleid[8], using a special type of Wöhler fatigue-testing machine, have shown that for a variable material, such as cast iron, tests must be made with caution. Preliminary investigations indicated that fatigue produced by a simple reversal of a bending stress gave results not very different from steel. Using an iron containing a fair percentage of silicon (2·42) and phosphorus (1·379), it was shown that if transverse strength by dead loading was taken as 100, fracture will occur almost immediately with a load of 65, and that a load of 43·5 will be endured for ten million reversals. Further tests by Bulleid and Almond[9], on two irons described respectively as suitable for light castings and as a typical cylinder iron, gave fatigue values of ± 6·4 and ± 3·2 tons for ten million reversals. Pearce[10], while accepting the test results, considered them as difficult to interpret owing to the position and types of the text bars and the composition of the two irons, and indicated that results obtained by the British Cast Iron Research Association did not show good cylinder irons to be inferior to other grades of iron in fatigue strength.

Research work on the fatigue strength of cast iron by Moore, Lyon, and Inglis[11] in America yielded some extremely interesting results. Test bars from four irons cast by different processes, and having approximately the same composition, were tested on a Wöhler testing machine, and had fatigue ranges of ± 5·25, ± 4·5, ± 4·25, and ± 3·25 tons per sq. in., respectively. These values were very uniform and consistent, as were also the tensile and compression tests; and the ratio of fatigue limit to tensile strength for three of the irons was approximately 0·35, and for the first iron cast by the centrifugal process 0·46.

Test bars from one of the irons were also tested both statically and under reversed bending stresses at temperatures ranging from atmospheric to 760° C. The tensile strength diminished from 13·4 tons per sq. in. at 20° C. to 11·2 tons at 425° C., and to 1·5 tons at 760° C. The fatigue values diminished more uniformly, being ± 5·3 at 20° C., ± 4·5 at 535° C., and ± 2·9 tons per sq. in at 760° C. There was, therefore, no great reduction of the endurance limit for temperatures below 425° C., and for temperatures over 650° the endurance limit was slightly higher than the tensile strength under a prolonged steady load, this method of loading being adopted for all the tensile tests, and being intermediate between rapid loading and creep testing.

These investigators submitted their cast irons to repeated stresses below the endurance limit and found the fatigue strength to increase by 30% and over, showing that cast iron is susceptible to understressing in a similar manner and degree to steel. Grooves cut in the cast-iron bars also reduced the endurance limit by a small amount; a very much greater reduction being obtained in the endurance limit of steel and copper by a similar groove.

Impact Testing.

The impact or shock testing of cast iron has been investigated by many workers, particularly on the continent, but no standard method of testing has yet been adopted. Cast iron is not a ductile material but rather the extreme opposite, being very brittle. There are, however, even in cast iron degrees of brittleness, which are not revealed by the ordinary tensile and transverse tests, and it is only by some form of impact test that such differences will be disclosed.

The usual form of impact tests are either single-blow tests or repeated-blow tests, and test bars are usually notched in some form or other to localise the fracture. Any form of notched test bar, and particularly the V-shaped notch of the Izod test bar, is detrimental with cast iron, being apt to accelerate the fracture due to the brittle nature of some of the constituents of the iron, graphite, and phosphide eutectic which might occur at the point of the notch. Results obtained from cast iron on small test bars, broken in the Izod and Charpy machines, are also considerably affected by the amount, shape, size, and distribution of the graphite flakes, so that results which have been obtained are not in general agreement.

An impact test described by Pearce[12], and used by the British Cast Iron Research Association, combines the sudden shock single-blow test with the rotary Wöhler test. A hammer of known weight falling from a known height 60 to 90 times per minute is allowed to strike a $\frac{5}{8}$-in. diameter test bar, with a groove in the centre, which is being rotated so that between each blow the bar is rotated through 180° C. The number of blows required to break the bar is recorded automatically. It is claimed that irons which yield good results under this test give good results under service conditions.

In general, impact tests on cast iron are difficult to determine. As regards composition and structure, it is accepted that iron with a low phosphorus content and having finely divided graphite is of higher impact value than irons where those conditions are reversed.

Hardness Tests.

There have been many methods evolved for the hardness testing of materials, and at present perhaps the most widely known is the Brinell test. This test has generally been considered an unsuitable test for grey cast iron, due to the fact that the structural components of cast iron consist of hard and soft constituents, and it depends on which of these constituents the ball comes in contact with.

During recent years attempts have been made to establish a relationship between the hardness of cast iron and its strength properties. After a series of tests, Portevin[13] stated that it was possible to establish, as in the case of steels, a definite relation between the hardness and tensile strength of cast iron. Schuz[14] showed that the tensile strength falls as the ball hardness diminishes, the curve following a straight line, and that a similar type of curve

is obtained for the relationship between combined carbon content and ball hardness, and that the size of the graphite flakes have little influence on the hardness. He concludes that the tensile strength of finished parts can be determined approximately from the ball hardness test.

More recent work, however, by the British Cast Iron Research Association has resulted in the opinion that an invariable relationship cannot be obtained, the tensile strength being principally governed by the size and distribution of the graphite, and the Brinell hardness by the amount and distribution of the phosphide eutectic. It was stated that no concordant results were obtained, on two samples of iron, by plotting either tensile or compression values against Brinell values, and that the formula proposed by Portevin and Schuz gave values 1·5 to 3 times as great as the actual tensile strengths.

Investigations have also been undertaken to correlate results obtained for the hardness of cast iron by the Brinell, Shore scleroscope, and other methods. Pinsl[13], working on phosphorus-rich irons, determined a series of ratios for various methods and stated they could be used with sufficient accuracy for a particular grade of iron, but that the hardness varied considerably with the composition and structure of an iron. Thomas and Bois suggest a ball hardness test as part of a general specification for cast iron. They consider that it, more than any other test, is more suitable as a commercial test for determining the homogeneity of a casting or of comparing castings produced in series.

Whether the Brinell hardness test can be used satisfactorily for grey cast iron or whether the results obtained can be compared with other properties is still a matter for discussion. For general use the Brinell hardness may be specified between 180 and 230 for medium and high-grade irons. Below 180 Brinell hardness there is a tendency for porosity in castings, and with a hardness value over 230 difficulty is experienced in machining.

Wear Testing.

The various investigations on the resistance of cast iron to wear have led to little agreement between the various investigators. Opinions differ as to the most satisfactory form of test, and also as to the influence which the various elements and constituents in cast iron have upon resistance to wear. Laboratory tests, as a rule, have not yielded results in accordance with service conditions without these conditions having been closely imitated. Hard cast iron with a combined carbon content have been considered by some investigators as most suitable to withstand abrasion, while others consider fairly soft irons with a large amount of free ferrite as more suitable, due to the fact that they take a high degree of polish. As far as can be seen there is no definite relationship between the Brinell hardness of an iron and its resistance to wear. Wear testing with or without lubricants also introduces complications.

Conclusions.

Consideration of the above methods of testing cast iron not only indicates the advances made during recent years, but also the present state of matters with regard to the testing of this very extensively useful alloy of iron. The methods of obtaining test bars, and of testing these bars, are a distinct advance upon previous practice. It can at once be seen that serious attempts are being made to meet actual service conditions, as far as possible, by co-ordinating properties of castings with properties of test bars.

The question of the test bar and whether it ought to be an independent unit, either attached to the casting, or cast separately from it, or whether it ought to form part of the actual casting has given rise to a considerable amount of discussion and controversy. Generally, British and American foundrymen and metallurgists favour the former type of cast bar, and French foundrymen the second type. A similar difference of opinion as regards the test to be adopted also occurs. The French view is that shear testing, transverse testing, and hardness testing of the small trepanned test pieces are the most representative, while the British and American view is in favour of tensile, transverse, and compression tests. As a result of this divergence of opinion, it would appear that the time is not yet opportune for drawing-up an international specification for the physical tests of grey cast iron.

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15 H. Pinsl, "Giesserei-Zeitung," 1928; vol. 25, p. 417.

B.E.S.A. SPECIFICATIONS.

THE British Engineering Standards Association has recently issued a revision of B.S.S. No. 91 Electric Cable Soldering Sockets for Cables from 0·003 to 1·000 sq. in. sectional area. The design and dimensions of cast and tubular sockets have not been altered, as compared with the previous edition of the specification, but an important modification has been made in that hot-pressed sockets are now recognised as standard, whereas formerly cast sockets and tubular sockets were the only types recognised as standard. The material for the manufacture of hot-pressed sockets is specified, as are also the dimensions. A useful feature of the revised specification is the insertion of tables giving the approximate current (at the I.E.E. rating) of the largest conductor for which the different sizes of socket are suitable. A new appendix has been added to the specification, giving the International Standards of resistance for copper.

Five new specifications have also been issued for non-ferrous metals. Two of these, Nos. 382 and 383 deal with 2/10/88 Bronze (Gun Metal) Ingots and Castings, respectively. The alloy corresponds very closely with that commonly known as "Admiralty Gun Metal," and the chemical composition and physical properties of the material are laid down. Another bronze specification, No. 384, is for Hard Drawn Phosphor Bronze Wire, primarily for armature binding. This specification covers two grades of wire.

The other specifications relate to Pure Aluminium, and deal with Tubes, No. 385, and Bars and Sections (excluding wire bars), No. 386. The chemical composition and physical properties of the finished material are specified, and clauses giving permissible margins of manufacture for the finished tubes, bars, and sections are included. Copies of these specifications may be obtained from the Publications Department, British Engineering Standards Association, 28, Victoria Street, London, S.W. 1, price 2s. 2d. *each*, post free.

Correspondence.

To the Editor, METALLURGIA.

Dear Sir,—In thanking Dr. Everest for his remarks upon my research on "The Effects of Nickel in Malleable Cast Iron," I would like to point out that the effects upon carbon have been deliberately omitted.

It has more influence on this than is generally known, and when I have confirmed my experiments of nickel upon carbon I shall publish them in the usual way. It may be interesting to state that I have succeeded in getting nearly 7% nickel in solution without a single trace of graphite in commercial practice.

I agree with the bulk of his remarks and hope that this work will stimulate further research in this direction.—Yours, etc.,

July 31, 1930. J. V. MURRAY.

METALLURGIA

The British Journal of Metals.

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METALLURGIA
THE BRITISH JOURNAL OF METALS.

The Iron and Steel Industry and the Sankey Report

ALTHOUGH the number of blast furnaces in operation varies according to the state of trade, quite apart from exigencies arising as a result of service, other factors frequently are responsible for the blowing-in of furnaces. It must be recognised that the British steel industry was developed originally by comparatively small individual firms which, as a result of amalgamations, have been placed on a more efficient and economic basis. The process of rationalisation which has resulted and which is extending, has caused the closing of redundant plants, and in this way has reduced the number of furnaces in blast. Modernising existing plants, in order to increase the output of individual units, have been instrumental in maintaining a higher rate of production from fewer furnaces.

While there can be no question that the reorganisation schemes, coupled with modern methods and processes, have reduced the need for the same number of furnaces formerly in blast, it is necessary to acknowledge that the present deplorable condition of the iron and steel industry is largely responsible for so many blast furnaces having been blown in during the last few months. The industry in Great Britain has been under a cloud for years, and the reorganisation efforts have not yet enabled manufacturers to view their future prospects with optimism. The position is worse than a year ago, and, while it would be idle to suggest that it has a permanent significance, it is necessary to acknowledge the facts and endeavour to seek out remedies.

It is untrue to say, as is sometimes alleged, that the equipment employed is inefficient, has a relatively low output, and that the methods of doing business leave much to be desired. This reflection on an industry that has been largely instrumental in placing Great Britain in the forefront among the nations is the reverse of optimism, and is dangerous to the prestige of the nation. It is well that Sir Arthur Dorman, chairman of Dorman, Long and Co., has called attention to this malicious form of criticism.

Modern engineering calls for a material homogeneous in composition and structure and capable of continuously resisting strains and stresses of ever increasing intensity. Close control of the methods of steel production and careful supervision of the processes of manipulation have enabled British manufacturers to keep in front of this demand for higher quality and greater durability. In the vital parts of modern structure British steel alone fulfils these exacting requirements.

It is not intended to convey the impression that all blast furnace plants are as efficient as could be desired; it must be remembered that the installation of new, and the modernising of available plant, to keep abreast of modern requirements is a heavy drain upon what is, in the majority of instances, a sorely depleted reserve, and when it is recognised that the industry is handicapped with heavy taxation in comparison with other nations, and that this additional cost must be borne by its products, it speaks well for British enterprise and quality of material produced that it is able to cope with keen competition to the extent that it does. That British iron and steel manufacturers have for many years been carrying out research work with a view to effecting real economy is amply borne out by the report of the sub-committee of the Sankey Committee appointed by the Government to investigate the condition of the industry. The investigations have proved that the allegation of inefficiency frequently directed against manufacturers is, in the main, unfounded.

It is interesting to note the views of the sub-committee of the Civil Research Committee after visiting the chief steel works of five continental countries and comparing the plants with those in this country. It reported that "as regards efficiency and management and the modernity and equipment of certain units of plant, they were equal to, and in some case superior to, the iron and steel plants which they had seen on the Continent."

It is not generally realised that British iron and steel manufacturers have been offering their products at prices between 15 and 20 per cent. above pre-war prices, while the cost of coal has varied between 25 and 75 per cent., labour from 66 to 100 per cent., and from 100 to 300 per cent. more for rates and taxes. In spite of these burdens the manufacturers have, since 1921, produced and sold steel nearer to the pre-war price level than either German or American steel makers, which indicates a very high degree of managerial efficiency.

The present condition of the industry is apparently due to causes over which the manufacturers have little or no control. They have accomplished much, and, although there has been considerable depression in the principal consuming trades, the output has been greater than before the war. This, however, is curtailed by the unequal trading conditions that exist. Only by operating plants to their utmost capacity can high efficiency be obtained. This is the secret of success, and the Continental iron and steel makers, having a highly protected home market, can produce more nearly at their maximum capacity, and, in addition to supplying their own market, can transport surplus to this country and market it at prices lower than production costs. These unfair conditions provide probably the greatest difficulty of the home manufacturers. It may not be realised that last year the difference between output in this country and the full capacity of which the various plants are capable was approximately equal to the amount of material imported. No other country tolerates this position without taking effective measures to restore a more even balance to protect its nationals' interests. Measures of this nature were in view when the Government

In addition to many other interesting features, a series of articles will commence in our next issue, entitled, "The Production of Aluminium Sheet," by Dr. Robert J. Anderson, and "Machinability," by Edward G. Herbert, B.Sc., M.I.Mech.E.

appointed the Sankey Committee to investigate the condition of the iron and steel industry. These investigations were completed some months ago, but as yet the report of the full committee, with its recommendations for uplifting the industry, has not been published. The Government have stated that negotiations are proceeding with the iron and steel manufacturers, but their nature has not been disclosed. No doubt, in the opinion of the Government, there are good and sufficient reasons for the delay in publishing the report, but can we be sure that steps are being taken to carry out the recommendations of the Committee with a view to restoring the industry? We are convinced that when the cloud of depression is lifted the technical developments that have been made in this country, both in regard to manufacture and quality of material, will retain for it a premier position in the van of progress.

TWO NEW CUNARDERS.

THE announcement that the Board of Trade, with the agreement of the Treasury, has decided to undertake insurance risks in connection with the new Cunard liner to be built by John Brown and Co., of Clydebank, and also a sister ship contemplated, is an indication of confidence in the future of British shipping, particularly in regard to the Cunard Line. The building of one vessel was entrusted to John Brown and Co. some months ago, but no contract was negotiated pending the settlement of some vital questions. Now that the Government has undertaken, at a premium, that part of the insurance not accommodated by the market in the ordinary way, the most important of these questions has been settled. A formal agreement, designed to apply to both vessels, will be attached to a Bill to be submitted to Parliament during the next session.

The Government is to be congratulated on taking this unprecedented action at a time when the shipbuilding returns, recently published, show the effect of the present world depression, particularly in view of the decrease in proportion of the world's shipbuilding, usually credited to this country, that is apparent. The present depression in the iron and steel industry is, in a measure, due to the decline in the demand for shipbuilding materials. As in the case of the ill-fated "Lusitania" and of the "Mauretania" it is anticipated that an agreement will be entered into between the Cunard Company and the Government indicating the conditions to be fulfilled in the construction of each vessel. It can be safely assumed that one of the primary objects in their construction is to restore to Britain the blue riband of the Atlantic, and one of the clauses in the agreement will probably stipulate the speed each vessel should be capable of maintaining during a voyage across the Atlantic, although the Cunard Company are not likely to give a guarantee of average speed from port to port. From the brief particulars available, in regard to size it would be no exaggeration to say that they will represent by far the most stupendous task ever entrusted to shipbuilders and marine engineers. In actual achievement, in all branches of shipbuilding, British shipbuilders have created a reputation of which they may well be proud, and their skill and resourcefulness will be taxed to the utmost in the building of these vessels, involving as they will the scientific solution of the most difficult problems in ship construction and marine engineering, in order to maintain the position of the Cunard Line in the forefront among Atlantic shipping lines, and, at the same time, preserve for Britain that prestige worthy of a great maritime power.

The courageous action of the Cunard Company is worthy of all praise. It is such enterprise as this that represents the fundamental characteristics of the British nation at its best, and a similar display of such courage in other industries would be instrumental in restoring a more optimistic spirit during this critical period and assist very materially in removing the industrial difficulties that are now the vital concern of everyone.

Autumn Meeting of the Institute of Metals.

THE Southampton meeting of the Institute of Metals, referred to in our July issue, which is to be held by invitation of the Mayor and Corporation of Southampton, from September 9–12 inclusive, promises to be exceptionally interesting. The proceedings will be opened on September 9, when the Ninth Autumn Lecture will be given by Professor D. Hanson, D.Sc. (Vice-President) on "The Use of Non-Ferrous Metals in the Aeronautical Industry."

On September 10 the proceedings will open at 9-30 a.m., when a civic welcome will be given by the Mayor of Southampton (Councillor Hector Young) in the Chantry Hall. Following this official opening of the Conference, the members will have a session of three hours during which time many papers will be submitted and discussed, as time permits. The papers presented will include :—

"Rolled Gold: Its Origin and Development," by Ernest A. Smith, A.R.S.M.
"Gas Removal and Grain Refinement of Aluminium Alloys," by W. Rosenhain, D.Sc., F.Inst.Met., F.R.S., J. D. Grogan, B.A., and T. H. Schofield, M.Sc.
"Pressure Die-Cast Aluminium Alloy Test-Pieces," by J. D. Grogan, B.A.
"The Diffusion of Aluminium in Iron," by N. W. Ageew, Met.Eng., and Olga I. Vher, Min.Eng.
"The Artificial Ageing of Duralumin and Super-Duralumin," by K. L. Meissner, Dr.-Ing.
"Lattice Distortion as a Factor in the Hardening of Metals," by W. L. Fink, M.Sc., Ph.D., and K. R. Von Horn, M.S., Ph.D.
"A Study of the Relation between Macro- and Micro-structure in Some Non-Ferrous Alloys," by Marie L. V. Gayler, D.Sc.

On September 11, at 9 a.m., further papers will be submitted and discussed, as time permits, and which will include :—

"The Effect of Two Years' Atmospheric Exposure on the Breaking Load of Hard-Drawn Non-Ferrous Wires," by J. C. Hudson, D.Sc., D.L.C., A.R.C.S.
"The Open Air Corrosion of Copper. Part II.—The Mineralogical Relationship of Corrosion Products," by W. H. J. Vernon, D.Sc., Ph.D., and L. Whitby, M.Sc.
"Silicon-Copper Alloys and Silicon-Manganese-Copper Alloys," by E. Voce, M.Sc., Ph.D.
"A New Silicon-Zinc-Copper Alloy," by E. Vaders.
"The Effects of Phosphorus on the Strength of Admiralty Gun-Metal," by H. C. Dews.
"A Note on the Constitution of the Cadmium-Zinc Alloys," by D. Stockdale, M.A., Ph.D.
"Pendulum Hardness Tests of Commercially Pure Metals," by D. A. N. Sandifer, M.Sc.
"On the Determination of Crystallic Orientation," by Prof. Dr. G. Tamman.

Special arrangements have been made for the ladies not attending the meetings to visit Tudor House, the Old Town Walls, and Netley Abbey. In addition to social functions many visits have been arranged for members and their friends which should make this meeting of outstanding interest to all who participate.

For the convenience of visitors who have the week-end free, and who desire to cross the Channel and return in an Atlantic liner, a trip to Cherbourg and back, with an extension to Dinard by motor-coach, has been arranged The party will leave Southampton at noon for Cherbourg in the R.M.S. "Mauretania," spending the night of September 13 in Cherbourg. On September 14 arrangements have been made for a motor-coach trip to Dinard via Coutances, Granville, Pontorson, and Dinan, the night being spent at Dinard. On September 15, starting from St. Malo and passing through Parame, the route will be by Mont St. Michael—where a stop will be made for lunch and to inspect the famous abbey—and thence via a number of interesting towns in Brittanny and Normandy to Cherbourg, where the night will be spent, returning to Southampton on the following day in R.M.S. "Aquitania."

The trip should be particularly attractive as it can be made at an inclusive charge of £8 15s. 0d. Applications from persons desirous of taking part in the meeting and excursions should be addressed to the Secretary of the Institute of Metals, Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, London, S.W. 1.

ADVANTAGES OF ELECTRIC MELTING FURNACES.

By Fred W. Frice, Dr.Met. (E.g.).

THE steady and rapid increase in cost of raw material and labour, and the growing speed of production, even in a small foundry, make it essential to investigate very carefully the various melting processes employed, not only in relation to the complete utilisation of fuel, but also in regard to metal losses. In a country like Brazil, where technical development is not far advanced, many difficulties arise in foundries which cannot be traced back to their origin. After considerable experience with the difficulties arising from the use of various types of melting plant for small foundries, the writer is convinced that the only way to overcome them is by the employment of electric furnaces.

Careful investigations made in foundries which are considered good show the metal losses from crucible furnaces to vary between the following percentages :—

	%
Copper	1·5 to 3·8
Bronze (80 copper, 20 tin)	3·0 „ 5·8
Brass (40 copper, 60 zinc)	4·0 „ 5·8
Zinc	5·0 „ 7·2

In crucible furnaces the charge, the fuel, and the crucible material are to be held responsible for these losses. Filings, turnings, punch-bits, wire clippings, and similar material, if not briquetted, are of a very low grade of heat conductivity, demanding therefore a high superheating, which leads to a considerable evaporation. Old ingots with oxidised surfaces or inclusions of slags are equally subjected to heavy losses. Furthermore, there is no fuel which does not oxidise or sulphurise the open surface of the charge. The best kind of coke available in Brazil at a reasonable price contains as much as 0·4% sulphur, and the majority of well-managed foundries prefer to work on charcoal or on oil. Charcoal is becoming scarce, however, and the installation of oil-burning furnaces means a thorough transformation of the whole plant, which, in many cases, the owners do not want to undergo.

In regard to crucibles, those available on the Brazilian market, if imported, are too expensive, whilst those of native make are too porous and cause heavy losses.

In an open-hearth furnace the efficiency is even lower still ; besides, here the following disadvantages assume a very heavy character : the greater part of the heat is wasted before acting on the metal, the temperatures cannot be controlled within small limits, the desired composition of the casting cannot be assured, the furnace takes much space, demands a great deal of auxiliary labour and repair, and allows the escape of gases detrimental to the workmen around the installation.

What may be expected in a crucible furnace in relation to the modification of composition in a charge may be seen from the following figures observed by the author. In each instance considerable differences will be noted between the composition of ingots from the same charge.

Bronze : 84% Cu, 16% Sn, traces of Zn ;
verified after casting from crucible with 200 lb. charge :—
1st ingot : 85·6% Cu, 14·4% Sn,
2nd ingot : 84·9 Cu, 15·1 Sn—30 minutes after ;
Last ingot : 84·3 Cu, 15·7 Sn.

Ferro-bronze with 82·5% Cu, 8·55% Sn, 4·45% Zn, 3·95% Fe :
1st ingot : 84·8% Cu, 6·28% Sn, 3·85% Zn, 5·0% Fe.
5th ingot : 84·5% Cu, 6·35% Sn, 3·99% Zn, 5·12 Fe.

Leddel alloy, substituting brass :
Sample analysed : 5% Cu, 90% Zn, 5% Al.
Bottom of crucible : 6·5% Cu, 86·6% Zn, 6·9% Al.

Motor-car bearing :
Sample analysed : 65% Cu, 29% Pb, 1% Ni, 5% Phos. Zn.
Bottom of crucible : 68·6% Cu, 30·3% Pb, 1·05% Ni, traces merely of Zn.

Patent metal :
Sample : 7% Cu, 76% Sn, 17% Sb.
10·5% Cu, 73% Sn, 16·5% Sb.
7·8% Cu, 75·7% Sn, 16·5% Sb.
7·2% Cu, 75·9% Sn, 16·9% Sb.

In addition the thermal efficiency in a common crucible furnace hardly reaches 10%. This has been verified by the writer of this article in numerous tests. One example may be referred to here in which an oil fuel was used to melt down and superheat to 1,200°—116° C. above smelting point—a copper ingot of 38 kilogs. of weight and 25° of initial temperature ; 7·33 kilogs. of oil were spent.

	Cal.
Heat produced by 7·33 kilogs. of oil	79,164
Heat existing in 1 kilog. of copper at the fusion point (liquid state)	162
Heat in 1 kilog. of copper at 25° C. (0·0959 × 25 + 00001778 × 25^2)	2·36
	175·07
For 38 kilogs. of copper	6652·66

Furnace efficiency therefore was $\frac{6,653}{79,164}$, or 8·44%, whilst in an electric furnace the *total losses* amount merely to 10—12%.

The economy in using electric energy for foundry furnaces instead of crucible furnaces may be readily judged from the following actual running data, together with expenses ; the investigation having been made in works where the rate for electrical energy is relatively high—300 reis/kw.h.

A.—CRUCIBLE FURNACE, VALUE OF PLANT WHEN NEW $30,000 (£725 0s. 0d.).

Melting 1,000 kilogs. daily in four crucibles of two charges each per day, each crucible being good for 20 charges before being discarded ; price of one crucible $130.

		$
1. *Material*—		
Share of eight crucibles on 1,000 kilogs. : $\frac{8 \times 130}{20}$	..	52
Fuel : per crucible and charge 80 kilogs ; at $100/1,000 kilogs ; share on 1,000 kilogs. of melted metal		64
Furnace repair material		15
		$131
2. *Labour*—		
Smelter, acting as foreman	$15	
Helpers, $8 each	24	
Repair labour	8	
		47
3. Depreciation and interest on the plant, figured on an existence of three years 250 days each		40
4. Losses of 3% bronze, 30 kilogs. at $6/kilog.		180
5. Auxiliary services		10
6. Overhead and sundry expenses		10
Total		$418

B.—ELECTRIC FURNACE. VALUE OF PLANT WHEN NEW $50,000 (£1,220 0s. 0d.).

		$
1. Electric energy, 500 kw.h./1,000 kilogs., 300 reis/kw.h.		150
Furnace repair material 1,000 kilogs./24 hours		5
2. Labour :		
1 smelter as foreman	$21	
2 helpers, $10 each	20	
		41
3. Depreciation and interest on the plant, figured on an existence of 10 years 250 days each		20
4. Bronze lost, 5 kilogs. at $6 per kilog.		30
5. Auxiliary services		5
6. Overhead and sundry expenses		10
Total		$261

The difference indicates an economy of 37·56% in the run of an electric furnace as compared with a common crucible furnace. This with a relatively high cost of power ; but in many places in Brazil, where electric energy is very much cheaper, the difference in favour of the electric furnace is still more advantageous.

In view of the superiority of electric furnaces it is rather remarkable that up to now very few steps have been taken to improve small and medium-sized foundries with modern melting plant ; the representatives of American firms have recently directed their attention to this fact. It seems that very much can be done, especially for railway repair shops and ship-yard works, where a transportable small electric furnace might be introduced with great advantage.

Aluminium Alloys for Heat-Treated Castings

By
Dr. Robert J. Anderson.

ALTHOUGH many of the ordinary aluminium-casting alloys are susceptible of improvement as to mechanical properties by heat-treatment, a number of special alloys have been developed by metallurgists in recent years particularly for use in the production of parts for high-duty service. Such alloys are not only more responsive to heat-treatment (or the heat-treatment required is more simple), but they also yield much better mechanical properties than the alloys previously employed. While various heat-treatment processes may be, and are, applied to aluminium-alloy castings, the type of heat-treatment referred to here is that involving heating to a suitable temperature (solution treatment), followed by quenching and then ageing (precipitation treatment). The commercial application of heat-treatment processes to aluminium-alloy castings is one of the outstanding metallurgical developments of recent years. Heat-treatment in the light alloy field has resulted in radical departures in structural designs, revolutionized foundry methods and casting practice, and opened up many new markets for castings.

By suitable alloying and heat-treatment, aluminium-alloy castings are now being produced with a wide range of tensile properties and hardness. The tensile strength and elastic values obtained in certain heat-treated alloys is nothing short of remarkable. High purity aluminium (99·97% grade) has tensile strength of about 8,500 lb. per square inch, and Brinell hardness of about 16 (500 kg., 10 mm.). Impure aluminium (99+% grade) has tensile strength of about 13,000 lb. and Brinell hardness of around 25. The elongation of pure and impure aluminium is high, while the apparent yield point is low. The ordinary casting alloys employed ten years ago (and still used to-day) have tensile strengths in the range 18,000 lb. to 30,000 lb., Brinell hardness of around 65 to 85, and low elongation—0·5 to 5%). The figures just given refer to sand-cast materials. As indicating what may be done by suitable alloying and heat-treatment, the tensile strength may be raised to, say, 50,000 lb., and the Brinell hardness as high as 160. A combination of high strength and ductility in cast aluminium alloys is obtainable only by heat-treatment. With certain alloys, it is possible by heat-treatment to more than double the tensile strength and elongation, increase the hardness by 75%, and triple the yield point. In other alloys a given heat-treatment may have little effect on the hardness or strength, but will triple the elongation. In still others, the strength and hardness may be raised about 50% each, while the elongation is but little affected.

Although some alloys give very interesting results on heat-treatment, they are not easy to cast in the foundry. Special technique has been worked out for pouring the newer alloys, particularly as regards feeding and controlling contraction. Since the mechanical properties obtained in a casting on heat-treatment are considerably dependent upon the soundness of the original casting, it is necessary to eliminate such defects as cracks and internal shrinkage cavities. The production of sound castings free from defects has been one of the more important problems involved in the commercial introduction of heat-treated aluminium-alloy parts.

It is of more than passing interest to point out that none of the aluminium alloys used to-day for heat-treated castings was found by accident, but rather was developed by systematic research. While the number of alloys employed in practice at the present time is few, many more will doubtless be introduced in the future. This development will come in part from the desire of founders and users to get around existing patent claims, and in part from the demand for a wider selection of alloys having specific properties. It is quite unlikely that new alloys of value will be found in the future, other than by scientific research.

Although heat-treated aluminium-alloy castings were first marketed about 1920, the development for the first few years thereafter was slow. Consumers were naturally reluctant to adopt a product that was not only untried, but more expensive, while foundrymen were loth to undertake their manufacture because of unfamiliarity with the requirements and methods of production as well as uncertainty as to the probable demand. However, since 1925 there has been a rapidly growing demand for heat-treated castings by a wide variety of consumers, and very substantial tonnage is being made to-day. It is expected that in the future the bulk of requirements in aluminium-alloy castings by the engineering trades will be in the branch once known as "special"—*i.e.*, special composition and heat-treated.

Alloys for Heat-treating.

While a great variety of aluminium alloys has been suggested, patented, and actually used, the bulk of present commercial requirements for heat-treated castings can readily be met with a relatively few compositions. The chief alloys that have been, or are, used in practice include certain compositions in the aluminium-copper, aluminium-copper-magnesium, aluminium-copper-nickel, aluminium-copper - silicon, aluminium - copper - iron - magnesium, aluminium - copper-iron - magnesium - silicon, aluminium-copper-magnesium-nickel, aluminum-copper-magnesium-silicon, aluminium-copper-nickel-silicon, and aluminium-silicon systems. Most alloys used commercially to-day contain one or more of the alloying elements—copper, iron, magnesium, nickel, or silicon. There are sundry proprietary alloys being marketed especially for heat-treated castings, but these need not be referred to by name here. They fall into one of the general classes to be discussed below. Many of the alloys proposed for heat-treatment have been patented, as well as their heat-treatment schedules, or are covered by pending patents or applications. Survey of the patent literature reflects the fact that almost every conceivable alloy and method of heat-treatment have been covered.

As is well known, the response to heat-treatment of an alloy depends in large part upon the varying solubility in the solid state of the alloying element (or elements) with the temperature. Another factor of importance is the metallographic condition of the alloying elements. Through fundamental research by many investigators, the solubility relations of the ordinary alloying elements used in aluminium (as well as of impurities) have been rather well worked out. Some of these relations are quite complicated, and other are not yet thoroughly understood. Study of the metallographic constitution of a number of aluminium-alloy systems at the aluminium end, together with practical experience, have shown that the alloys are highly sensitive to slight changes in chemical composition. While the differences in composition between two alloys may appear

to be minor, particularly as regards impurities, these differences may readily account for success or failure in heat-treating. While any detailed discussion of this aspect of the subject is beyond the purview of the present article, emphasis is to be laid upon the fundamental importance of adequate chemical and metallographic control in the production of heat-treated aluminium-alloy castings.

The first alloy of note brought out for heat-treated castings had the nominal composition 92·5 : 4 : 1·5 : 2 aluminium-copper-magnesium-nickel. This was developed at the National Physical Laboratory in England, and was referred to as "Y." This alloy is one of the best all-round aluminium alloys for both casting and working. It finds general application in England for high-duty heat-treated castings, and is used to some extent in the United States, particularly for pistons and cylinder heads for radial aviation engines.

Aside from the "Y" alloy, there are two main classes of alloys used in the United States for heat-treated castings—viz., (1) the low-copper type, and (2) the high-copper type. The former is exemplified by alloys containing, say, 2·5 to 5% copper (with or without magnesium, iron, or silicon), and remainder aluminium, and the latter by alloys containing about 10% copper (usually with magnesium), and remainder aluminium. The low-copper alloys are used for castings postulating mod rate to high strength and high to fair elongation, together with moderate to high hardness, and superior resistance to shock or alternating fatigue stresses. The high-copper type is used chiefly wh re high Brinell hardness is demanded—mainly in heat-treated pistons for motor-cars. In the United States the low-copper type finds general application for heat-treated castings, barring pistons. Fair strength, poor elongation, and high hardness are the combination of properties secured with the high-copper type. The properties obtained with the low-copper type may be varied very considerably, depending upon the heat-treatment; this will be explained more fully under effect of heat-treatment on mechanical properties, below.

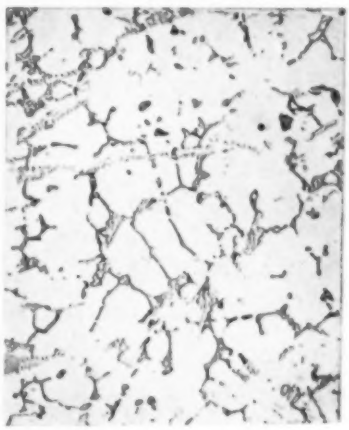


Fig. 1.
Microstructure of 92.5 : 4 : 1.5 : 2 aluminium-copper-magnesium-nickel alloy; sand cast; etched H F; × 100.

Fig. 2.
Same as Fig. 1; but × 1,000.

Among specific compositions that may be mentioned as heat-treating alloys, the following may be noted:—96 : 4 and 95 : 5 aluminium-copper; 95·8 : 4 : 0·2 and 94·75 : 5 : 0·25 aluminium-copper-magnesium; 94 : 4 : 2, 94 : 5 : 1, and 93 : 2 : 5 aluminium-copper-silicon; 88·5 : 10 : 1·25 : 0·25 aluminium-copper-iron-magnesium; 88·75 : 10 : 0·25 : 1 aluminium-copper-magnesium-silicon; 92·5 : 4 : 1·5 : 2 aluminium-copper-magnesium-nickel; and 95·5 aluminium silicon. It is understood, of course, that these alloys are made from commercial aluminium containing the usual impurities. Certain alloys in the range of composition 2·5 to 5% copper, 0 to 1 magnesium, 0·2 to 1 silicon, 0·3 to 1·5 iron, and 0 to 1% manganese (remainder aluminium) are also used for heat-treated castings. The chief requirements of the U.S. Army Air Service in heat-treated cast parts are met with four alloys. These include the 88·5 : 10 : 1·25 : 0·25 aluminium-copper-iron-magnesium alloy (for pistons and bearings), the 92·5 : 4 : 1·5 : 2 aluminium-copper-magnesium-nickel alloy (for pistons, air-cooled cylinder heads, and bearings), the low-copper type having the nominal composition 95·75 : 2·5 : 1·25 : 0·5 aluminium-copper-iron-magnesium (for housings and bracket), and the 94 : 5 : 1 aluminium-copper-silicon alloy (for crankcases, water jackets, levers, and wheel spiders). This latter alloy is similar to several other alloys of the 95 : 5 aluminium-copper type.

Current revised specifications of the Society of Automotive Engineers for general heat-treated castings call for the 95 : 5 aluminium-copper alloy (S.A.E. specification No. 38). The limits of chemical composition are—

Copper	4·0 to 5·0%
Silicon (maximum)	1·20%
Iron (maximum)	1·20%
Zinc (maximum)	0·25%

Total of all constituents except aluminium and copper is to be not over 2·5%.

When high resistance to shock and maximum toughness are required, heat-treatment consists in soaking, quenching, and air ageing. So treated, the tensile strength is about 33,000 lb. per square inch, and the elongation about 9% (in a 2 in. length) for sand-cast bars. The strength increases somewhat more, and the elongation decreases on air ageing for several months, while the yield point rises to well over 20,000 lb. If greater strength, yield point, and hardness are required the alloy is aged (after quenching) at moderately elevated temperature, to give about 36,000 lb. tensile strength and 5% elongation. The ageing treatment may also be varied to provide tensile strength of around 45,000 lb. and elongation of about 2%

Microstructure as Affected by Heat-treatment.

Heat-treatment has profound effect on the microstructure of the aluminium-casting alloys, as would be expected. Speaking generally, the microstructure of as-cast aluminium alloys of the heat-treatable type consists of the aluminium-rich solid solution and a more or less continuous intergranular network of the alloying constituents. The brittleness (lack of ductility) in the as-cast alloys is properly ascribable to this network. In binary aluminium-copper alloys, the network consists of the intermetallic compound $CuAl_2$, which is hard and brittle. Roughly, the effect of heat-treatment is the total or partial elimination or breaking up of the network structure.

In high-copper alloys of the piston type (10% copper), the network is continuous, and is only partly broken up by the solution heat-treatment. In low-copper alloys, however, the network is not continuous, and may be eliminated or well broken up by the solution heat-treatment. While the hardness and strength of the high-copper alloys may be considerably enhanced by solution and precipitation treatment, not much effect can be produced in the case of the elongation. In the low-copper alloys, all, or the great bulk, of the $CuAl_2$ network may be taken into solution so that the hardness, strength, and elongation may be substantially increased. Of course, in the case of polynary alloys, the network may be very complex and include several constituents. Such constituents are, however, all hard and brittle, and their total or partial elimination (by solid solution or change of form—spheroidisation) is the aim of heat-treatment. The time period of soaking prior

to the quench is determined in large part by the nature and condition of the network structure. Hardening on ageing is the result of the precipitation of the constituents, taken into solution at elevated temperatures, on standing at the ordinary temperature or on heating at moderate temp ratures.

Some low-copper alloys of the Al-Cu-Mg_2Si type are particularly well adapted to heat-treatment. In such alloys, most of the $CuAl_2$ constituent and Mg_2Si are in the form of a finely divided filigree (probably as a ternary eute tic with the aluminium-rich solid solution). The small particles of the filigree go into solution very much more rapidly than do segregat · plates of intermetallic compounds. Thus, it has been found through research by the U.S. Army Air Service that, in alloys of the type just mentioned, when copper is present in amount over 2%, and magnesium is absent or present in quantities less than 0·25%, the copper will be found entirely as a segregate of massive $CuAl_2$. No filigree will be found until the magnesium is increased sufficiently to convert part or all of the silicon into Mg_2Si. In an alloy containing 2% copper, with the silicon impurity 0·25%, it has been found that nothing but filigree will appear in the microstructure if the magnesium content is 0·45%. Hence, by suitable adjustment of the chemical composition—at least in some alloys—it appears that the bulk of the intermetallic compounds present may be made to form a filigree structure as contrasted with a structure made up of a network or of massive segregate particles. The time period required to break up a structure containing a network or segregate particles is much longer than in the case of the filigree. Further study is required to determine just what may be done in the way of controlling the original structure of the as-cast alloy.

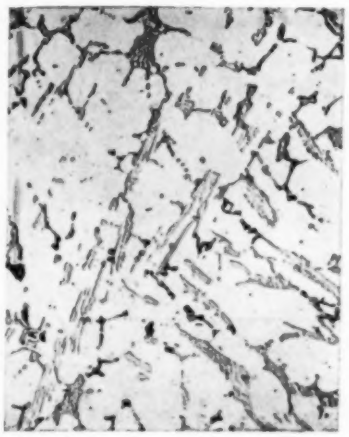


Fig. 3.
Microstructure of 92.5 : 4 : 1.5 : 2 aluminium - copper - magnesium - nickel alloy; sand cast and heat treated; etched H F; × 100.

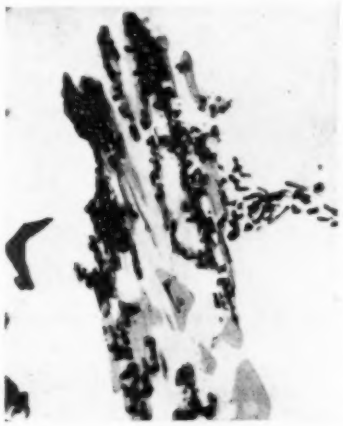


Fig. 4.
Same as Fig. 3; etched HNO_3 quench; × 1,000.

Figs. 1 to 4, inclusive, show some microstructural features of the 92·5 : 4 : 1·5 : 2 aluminium-copper-magnesium-nickel alloy, as cast and heat-treated. These micrographs were taken in the laboratories of the U.S. Army Air Service. Fig. 1 shows the average structure of the alloy as sand cast, and Fig. 2 shows a portion of this structure at high magnification. Fig. 3 shows the average structure of the cast alloy after heat-treatment, and Fig. 4 shows a portion of this structure at high magnification. The heat-treatment involved consisted of soaking for five hours at 950° F., followed by quenching in boiling water, and then ageing for 16 hours in boiling water. As described by Daniels, the sand-cast alloy has a rather open network structure, a small amount of $CuAl_2$ (either as filigree or in triangular patches), a larger amount of Mg_2Si (in skeletons or in filigree), a large amount of $NiAl_3$ (often segregated) in stringers, needles, or skeletons, slightly less T (the ternary compound of aluminium, copper, and nickel), and a small amount of $FeAl_3$ in the form of needles, distinguishable with difficulty from the T. Some few needles of constituent X (Fe-Si-Al ?) are also present. No intragranular precipitate is present in the matrix. When quenched and aged there is some dissolution of the network by absorption of all of the $CuAl_2$, some $NiAl_3$, and possibly some T. The Mg_2Si and the iron-bearing constituents were evidently not affected by the particular treatment above mentioned. The microstructure of the 92·5 : 4 : 1·5 : 2 aluminium-copper-magnesium-nickel alloy is much more complex than that of the usual alloys of the 95 : 5 aluminium-copper type, or of the high-copper piston alloy.

Effect of Heat-treatment on Mechanical Properties.

The number of data available regarding the effects of various heat-treatments on sundry mechanical properties of different cast aluminium alloys is now very numerous. Detailed information may be had from the large literature on the subject, and in the present article only a few data will be given to show the trend of the figures. The mechanical properties resulting from heat-treatment are intimately connected with the composition of the alloy used, the initial microstructure, the method of casting, and soundness of original casting, and the heat-treatment itself. It is important here to point out that the mechanical properties obtained in production castings are not ordinarily so good as those given by test-bars. This naturally follows because of the mass effect and the fact that laboratory methods of handling and control cannot be readily or economically put into production practice.

In alloys of the low-copper type—*e.g.*, 95 : 5 aluminium-copper,—by variation in the ageing treatment after quenching, variable mechanical properties may be obtained as follows :—

(1) Very high tensile strength with low elongation.
(2) High strength (but lower than 1) with fair elongation.
(3) Moderate strength (but lower than 2) with high elongation.

The combination of highest strength and low elongation is secured by protracted exposure at the proper ageing temperature, after quenching, so that full precipitation (short of coalescence and agglomeration) is obtained. The combination of high strength and fair elongation is obtained by a shorter exposure at the ageing temperature—precipitation is not complete. The combination of moderate strength with high elongation is obtained by air ageing, after quenching, or with very short exposure at a moderately elevated ageing temperature. Air quenching after soaking at the solution temperature may be employed in heat-treating castings instead of water quenching. The specific heat-treatment to be used depends in part upon the mechanical properties desired and the nature of the castings. Air-cooled cylinder heads in the "Y" alloy are usually air quenched to avoid warping of the fins; they are then aged by short exposure at moderate temperature—*e.g.*, one hour at 400° F.

TABLE I.

SOME MECHANICAL PROPERTIES OF 94 : 5 : 1 ALUMINIUM-COPPER-SILICON ALLOY, AS SAND CAST AND HEAT TREATED.*

Property.	As Cast.	Heat Treated.†
Tensile strength, lb. per sq. in.	21,500	31,000
Proportional limit (tension), lb. per sq. in. .	4,900	8,600
Elongation, on a 2 in. length, %	2·2	5·5
Compressive strength, lb. per sq. in.	35,100	43,700
Charpy impact resistance, ft.-lb.	1·4	3·2
Brinell hardness, 500 kg., 10 mm. ball ...	60	75

†For heat-treatment, see text, *Tests by Daniels and Warner.

Table I. gives some data (obtained in tests by Daniels and Warner at the laboratory of the U.S. Army Air Service), showing the effect of a heat-treatment on various properties of a sand-cast alloy containing about 4·9% copper, 0·8% silicon, 0·6% iron, and remainder aluminium. The heat-treatment entailed soaking for 24 hours at 950° C., followed by quenching in boiling water, and then ageing for two hours at 250° F. It will be noted that the tensile strength has been increased by about 50%, the proportional limit nearly doubled, the elongation more than doubled, and other mechanical values substantially increased. Table II. gives some data (obtained in tests by Daniels at the laboratory of the U.S. Army Air Service), showing the effects of different heat-treatments on some mechanical properties of the 92·5 : 4 : 1·5 : 2 aluminium-copper-magnesium-nickel alloy ("Y"). It is shown that the strength but little affected, by quenching treatment. Relative response to heat-treatment of sand- and chill-cast bars of the same alloy may be noted in the last two sets of figures in the table (referring to the alloy containing 4·87% copper, 0·31% magnesium, 0·56% silicon, 0·75% iron, and remainder aluminium). Considerably higher strength and elongation are obtained with the chill-cast material. Very high Brinell hardness is obtained with suitable heat-treatment of the 88·5 : 10 : 1·25 : 0·25 aluminium-copper-iron-magnesium alloy, chill cast (*cf.* Table III.).

TABLE II.

EFFECT OF DIFFERENT HEAT-TREATMENTS ON SOME MECHANICAL PROPERTIES OF SAND-CAST "Y" ALLOY.*

Condition of Test Sample or Heat-treatment.					Mechanical Properties.		
Time of Soak, Hours.	Temperature of Quenching, ° F.	Quenching Medium.	Time of Ageing, Hours.	Temperature of Ageing, ° F.	Tensile Strength, Lb. per Sq. In.	Elongation on a 2 in. Length, %.	Brinell Hardness, 500 kg., 10 mm.
As sand cast—not heat-treated					25,000	0·7	75
Air aged 6 months, after casting					28,400	0·5	96
5	950	Boiling water	16	212	37,000	0·5	97
5	950	Boiling water	2	400	36,700	0·5	105
5	950	Boiling water	16	400	39,300	0·5	105
4	950	Boiling water	1	450	35,400	0·5	109
1	950	Boiling water	30 days	room temp.	33,800	0·5	89
1	950	Boiling water	Tested imm	diately ..	29,400	1	80

*Tests by Daniels.

As has been indicated, chill castings respond more readily to heat-treatment than sand castings—*i.e.*, the time period of soaking at the quenching temperature is much shorter in the case of the former, and the mechanical properties obtainable are better. The fact that chill castings are more desirable for heat-treatment than sand castings is

TABLE III.

EFFECT OF HEAT-TREATMENT ON THE TENSILE PROPERTIES AND HARDNESS OF SOME CAST ALUMINIUM ALLOYS.*

Composition of Alloy.	Time of Soak, Hours.	Temperature of Quenching, ° F.	Quenching Medium.	Time of Ageing, Hours.	Temperature of Ageing, ° F.	Tensile Strength, Lb. per Sq. In.		Elongation on a 2 in. Length, %.		Brinell Hardness, 500 kg., 10 mm.	
						As Cast.	Heat treated.	As Cast.	Heat treated.	As Cast.	Heat-treated.
5 Si, 0·4 Fe; sand cast	96	1,024	Cold water	8	300	18,300	20,000	8	17	34	32
5 Cu, 1 Si; sand cast	24	950	Boiling water	2	300	21,500	31,000	2	5	60	75
4 Cu, 0·25 Si, 0·4 Fe, 0·5 Mg, 0·75 Mn, sand cast	5	925	Boiling water	11 days	room temp.	21,000	32,000	1	0·5	66	93
1·16 Mg, 1·02 Si, sand cast	96	1,026	Cold water	8	300	17,900	34,100	3	6·3	48	65
4 Cu, 1·5 Mg, 2 Ni, sand cast	5	950	Boiling water	16	400	25,000	39,000	0·7	0·5	75	105
2·5 Cu, 0·5 Mg, 1·25 Fe 0·25 Si; sand cast	2	968	Boiling water	2	300	25,000	31,000	5	3	60	67
10 Cu, 1·25 Fe, 0·25 Mg, sand cast	5	925	Boiling water	16	300	26,000	35,000	1	0·5	88	120
10 Cu, 1·25 Fe, 0·25 Mg, chill cast	4	950	Boiling water	3	420	27,000	40,000	1	1	95	160
2 Cu, 10 Zn, 0·25 Mg, sand cast	3	920	Boiling water	3	212	25,000	34,200	1·4	2	60	80
13 Si; chill cast, modified	2	1,031	Cold water	not aged	—	31,000	30,000	6	18	60	48
4·87 Cu, 0·31 Mg, 0·56 Si, 0·75 Fe, sand cast	96	950	Cold water	8	300	21,000	37,000	2	3	60	80
4·87 Cu, 0·31 Mg, 0·56 Si, 0·75 Fe, chill cast	96	950	Cold water	8	300	24,000	43,000	3	6	62	83

*Data from various sources (chiefly tests by Daniels and associates at laboratory of U.S. Army Air Service.

tensile strength and Brinell hardness may be increased about 50% by suitable heat-treatment. Table III. gives some figures for the tensile properties and hardness of various alloys as cast and heat-treated. The elongation of the sand-cast 95 : 5 aluminium-silicon alloy is more than doubled, the tensile strength slightly increased, and the hardness but little affected by quenching and ageing. In the case of the chill-cast 87 : 13 aluminium-silicon alloy (modified), the elongation is tripled, and the hardness and explained in part by the better original properties and structure of the former and their greater soundness. The permanent-mould process for producing aluminium-alloy castings has enjoyed increasing vogue with the development of heat-treatment. Heat-treatment has a marked effect on the machinability of aluminium-alloy castings, and this must be taken into account in tooling operations. It also improves the corrosion resistance of certain alloys.

To sum up: The primary object of heat-treatment

(*Continued on page* 154.)

Refining Steel Ingots by the Miris Process.

By Edward D. Lacy.

AT a time when the heavy industries of the United Kingdom have reached the depths of depression, any method or process which tends to enhance the quality of basic products, at the same time reducing the cost of failures, and in some cases reducing the working costs of production, should be studied very carefully indeed.

During the World War a process named "Miris" (from the Latin word meaning wonderful) was applied chiefly to the production of bullet-proof steel with such success that at the time of the armistice the comparatively small Miris Steel Co. were supplying no less than 50% of the country's total output—that is to say, as much as all the armament firms put together. Owing to its wonderful uniformity and the simplicity of its manufacture and subsequent treatment, failures were reduced to an amount hitherto unknown, in addition to which the price charged for this steel was understood to be consistently lower than that of the armament firms. At this juncture it is interesting to recall that the British Government considered the Miris patents so valuable that they prohibited the publication of any particulars relating to this process, and at the same time withheld permission to apply for patents in certain other countries.

Foreign Governments have also been on the market, but there was a natural lull in the years immediately succeeding the war, but at the present time there is a fair demand for protective material.

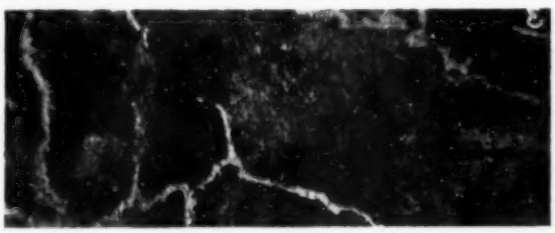
Steel whilst in ingot form is subjected to a chemical treatment at predetermined temperatures, varying with the grade of steel being dealt with. The ingots are subsequently reheated, cogged, and rolled in the usual manner, according to the purpose for which the steel is intended, the improvement effected never being eliminated. Steel whilst still in the ingot form is therefore brought to a refined condition, the refinement of grain structure persisting throughout all the subsequent stages of rolling and working, the effects of the process not being destroyed by subsequent heat-treatment. No special precautions are necessary whilst working the steel. In fact, due to its refined structure, more latitude can be allowed in the matter of temperature than for ordinary steel.

Possibilities of the Miris process are demonstrated by the following facts. In the untreated condition an acid or a basic charge which could not have been accepted for the most ordinary purposes, yet the Miris treatment regenerated the steel, which then not only met the specification but afforded a considerable margin on each of the factors.

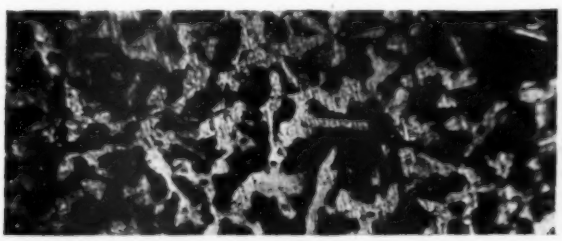
The remarkable improvement effected on otherwise poor steel is indicative of what can be done and what an asset the Miris process can be to a steel manufacturer, namely, to have a complete charge of steel put into such a condition that it becomes acceptable, whereas it would otherwise be entirely scrapped. This is a phase of the situation which should be borne in mind in view of the low grade of raw material now on the market, and at a time when British steel manufacturers are greatly handicapped, owing to competition caused by the dumping of inferior foreign steel, the value of the process can be realised.

It would, however, appear that the steel trade generally have only known of the application of the Miris process to the manufacture of bullet-proof steel. A company is now in formation which will treat all kinds and grades of steel for general engineering purposes.

Claims made for Miris steel are as follows :—Homogeneity and uniformity. Refinement of grain structure. Much-improved working qualities: high-carbon steel being easily sheared and worked. Increased ductility coupled with high ratio of elastic limit to ultimate tensile strength.



Untreated Basic.
Tensile 40 Tons. Elongation 6%. Reduction of Area 9%.



Treated Basic.
Tensile 43 Tons. Elongation 30%. Reduction of Area 34.6%.

Mag. 1". × 250 Dias.

Weld-ability. Even high-carbon Miris steels are easily welded. Lack of scale. Improvement effected in all grades of steel from the lowest to highest carbon steels. Applicable to S.M.O.H. Acid or basic straight carbon or alloy steels, and also to crucible steels. The poorest grades of steel are greatly improved by being treated by the Miris process. The steel can be annealed dead soft without impairing its improved properties. Improved turning qualities, giving an excellent finish. Deleterious effects of phosphorus are overcome to a certain extent. Ingots are partially degassed. When kept at very high temperatures after long periods Miris steels have been unaffected, whilst untreated steels have been completely destroyed. Miris steels stand punching, shearing, cold bending, or any form of cold working better than untreated steels.

Miris straight carbon steels can be used for all purposes where an improved quality of steel is desired, for instance, for forgings, drop forgings, stampings. Deep pressings, and high-strength pressings. Cold-rolled, close-annealed sheets. Cose-annealed sheets and black sheets. Ship, tank, boiler bridge, etc., plates. Turning qualities of steel. Free-cutting steel. Shafting. Automobile work in general. Axles and pins. Locomotive frames, piston rods, draw-bars, etc. Bright-drawn bars. Cutlery, razor blades, etc. Balls for ball mills, die blocks, rails generally. Wire rope, springs. Whitworth taps. Lathe centres. Chisels, files, setts, drills, punches, snaps, shear blades, ball races, mandrils, knives, crowbars, rock drills, caulking tools, coal cutters, mining steels, hammers, etc., etc. Case-hardening. For general and special engineering, shipbuilding, motor, etc., work, where a better grade of steel than the ordinary commercial quality is desirable.

Miris 4% nickel steel is recommended for all bullet-proof protection. Trench helmets, armoured cars, tanks, etc.

Hard-wearing parts such as dredger buckets lips, etc., displacing manganese steel, shear blades, etc. Shafts, etc. Valves for motor-cars, etc.

A number of very excellent testimonials from users of Miris steel have been received, the most remarkable perhaps being from Samuel Butler and Co., Ltd., of Stanningley, near Leeds, who stated the following with reference to their shear blades. Owing to the fact that they were made of Miris steel they needed practically no grinding, thereby reducing the wear and tear to an infinitesimal amount, resulting in the fact that these blades would not have to be replaced for many years to come.

Among the reports received from eminent metallurgists and chemists, the following from the late Professor Longbottom testifies the remarkable qualities of Miris steel :—

Tests of Miris Steel Bars.

" In the testing of the small bars very remarkable results were obtained : the 0·322- in. bars 12 and 15 gave a very *distinct yield at* 85% *of the maximum stress*, and the 0·252-in. bars at *about* 92% *of the maximum stress*. These ratios of yield to maximum are extraordinarily high, but there was no *mistaking the facts* ; the drop of the steel yard was quick and complete, and in the first test it remained so long on the lower stop before recovery that it appeared as if the material had reached its maximum stress. There was a repetition of this phenomena with each of the small bars. Below these high yields the stretch was extremely small, and it was only by very careful observation in testing the duplicate bars marked " B " that a very slight stretch was detected in each case at from 54 to 56% of the maximum stress. These lower values are, of course, not necessarily yield stresses, they more probably mark the limits of proportionality, and the slight stretches would likely be elastic, and would have disappeared if the load had been removed. It is noticeable that the lower ratios agree very closely with the ratios between the limit of proportionality and the maximum stress as determined by the extensometer on the 1-in. bars. I therefore conclude that the higher values do really represent the true yield stresses of the smaller bars.

The very close agreement of these figures for all the different sizes of bars is noticeable and indicates a good uniform quality of material.

A set of results indicative of material of *exceptionally high and uniform quality.*

The ductility of the special steel bars compares extremely well with milder steels, and their advantage in strength is remarkable.

The special steel bars possess remarkably good qualities. In addition to high yield and high maximum stress, the material possesses considerable ductility, and is of a very uniform quality. Its physical properties closely resemble those of a 3% nickel steel, and it compares well both as regards strength and ductility with the chromium and manganese given in table " G."

This material should soon remove the long-standing prejudice against basic steels, and if it can be produced comparable with that of the ordinary acid and basic mild steels, its extensive employment seems assured.

Combining high elastic and ductile properties with high strength it appears to have a wide field of application in engineering construction. Its employment, for example, in bridge work, and in ship construction would lead at once to very considerable reductions in scantlings, with consequent saving in deadweight, and perhaps also in cost."

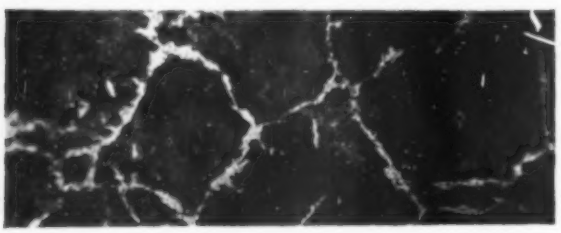
Some time ago five grades of Miris steel were forwarded to the firm of Mechans, Ltd., Scotstoun Ironworks, Glasgow, for pressing into side members of motor-car frames.

Three grades (A, B, and C) were supplied to meet their mild-steel, high-tensile-steel, and nickel-steel specifications, respectively, the results being as indicated.

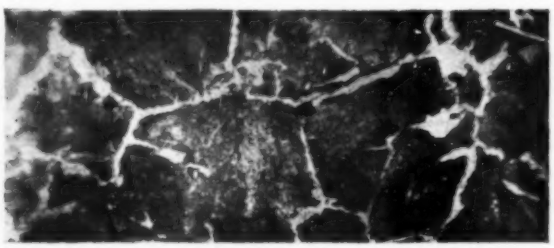
The other two grades were high-strength steels, in one case the carbon being as high as 0·70%, viz., a tool steel.

All five grades were pressed up in the usual manner and machined quite easily. No special care was taken in cutting off the test bars which were submitted to Messrs. Kirkcaldy and Son, testing and experimenting works, London, with results as shown in the following tables.

It will be seen that the yield point on each of the three grades, A, B, and C, as pressed up, is much above that specified, being on grade A 9·3 tons, and on grade B 8·3 tons above the acceptable minimum ; whilst the yield point on grade C (which is a pure carbon steel containing no nickel whatever) is 6·4 tons in excess of that specified for nickel steel.



Untreated Acid.
Tensile 51.5 *Tons. Elongation* 12%. *Reduction of Area* 9.5%.



Treated Acid.
Tensile 51 *Tons. Elongation* 25%. *Reduction of Area* 28.7%.

Mag. V. × 250 *Dias.*

GRADE A.

Tests.	Ultimate Strength Tons per Sq. In.	Yield Point Tons per Sq. In.	Elongation.	Ratio Yield to Ultimate %	Nature of Fracture.
		Not less than	Not less than		
As specified	26·32	14	20% on 8 in.	—	—
On steel supplied	30·5	25·2	40% on 2 in.	82	—
After pressing ..	29·4	23·3	29·5% on 2 in.	79	Silky
After annealing..	28·1	24·1	33% on 2 in.	86	Silky

GRADE B.

Tests.	Ultimate Strength Tons per Sq. In.	Yield Point Tons per Sq. In.	Elongation.	Ratio Yield to Ultimate %	Nature of Fracture.
	Not less than	Not less than			
As specified	36	20	16% on 8 in.	—	—
On steel supplied	38·1	25·7	38% on 2 in.	67·5	—
After pressing ..	39	28·3	23·5% on 2 in.	73	Silky
After annealing..	35·5	25·8	30% on 2 in.	73	Silky

GRADE C.

Tests.	Ultimate Strength Tons per Sq. In.	Yield Point Tons per Sq. In.	Elongation.	Ratio Yield to Ultimate %	Nature of Fracture.
	Not less than	Not less than			
As specified	40	24	20% on 2 in.	—	—
On steel supplied	47·7	37·9	23% on 2 in.	79	—
After pressing ..	44·2	30·4	20·5% on 2 in.	69	Silky
After annealing..	41·1	25·1	25·5% on 2 in.	62	Silky

Although such good results are obtained on Miris steel, it should be noted that these results are not obtained at the expense of the ductility.

Iron and Steel Foundry Practice

By Ben Shaw.

Difficulties in Steel Founding. Carbon and Alloy Steel Castings.

Part V.

(*Continued from page* 230, *Vol.* I.)

THE production of steel castings is perhaps the most difficult branch of the foundry industry. The difficulties encountered in the production of iron castings are intensified in steel castings, largely due to the increased casting temperatures necessary, the mechanical weakness of the steel immediately after its solidification, and its relatively high contraction. The casting temperature depends to a considerable extent upon the composition of the steel used, a dead mild steel requiring a higher pouring temperature than a high-carbon or high manganese steel. This is governed by the degree of fluidity, at a particular temperature, necessary to enable the steel to completely fill a mould without lapping. Generally speaking, this fluidity is directly connected with the amount of superheat above the melting point of the steel in question, although various other factors also affect the fluidity of steels. Nickel-chrome and silicon steels, for example, are sluggish even at temperatures well above their melting point, whereas manganese steel is very fluid at 1,450° C. The casting temperatures will vary with the thickness of metal required, and, as a rule, the thinnest section in a casting is a determining factor; thus, for mild and medium carbon steels the casting temperatures will approximate to the following:—

Less than ¾ in. sections	1,580-1,640° C.
Between ¾ in. and 2 in. sections	1,530-1,580° C.
Over 2 in. sections	1,500-1,550° C.

It is not, of course, the high temperatures that are the difficulty, but the effect they have upon the sand forming the moulds. In selecting sands for this work there are several essentials which must be kept in view, namely, refractoriness, adhesiveness, porosity, and permeability. Refractoriness is of primary importance for steel, and impurities which combine with silicon to form silicates at high temperatures and burn on the castings should be very low. One of the greatest difficulties, not yet thoroughly surmounted, is to preserve a good skin on steel castings, particularly where thick sections are concerned. In many foundries no improvement has been effected in this respect during the last 20 years. The quality of skin produced on a casting is largely dependent upon the refractoriness of the sand used, and the higher the percentage of impurities the lower its refractoriness.

Contraction Difficulties.

The high contraction of steel, combined with its low strength shortly after solidification, creates many difficulties in the production of castings. The casing of a mould is, in many instances, imperative, in order to release the casting and allow it to contract with as little strain between its members as possible. It is only by taking adequate precautions of this kind that many castings are prevented from rupture. Unequal thicknesses of metal will cool at different rates, and consequently will contract unequally, resulting in parts of a casting being in a highly stressed condition. The use of chills assists to effect a more regular rate of cooling, but strains are present in the majority of steel castings, and one of the reasons for their subsequent heat-treatment is the removal of these strains. Many of the difficulties associated with steel castings are being overcome and there is no doubt that during recent years the demands for steel castings has increased. At one time they consisted almost entirely of large castings, such as stern frames, and castings of a similar nature used in connection with shop construction, heavy castings associated with large forge hammers, blast-furnace castings, etc. Now, however, very considerable progress has been made in the use of steel castings, particularly for work of smaller size, not only in carbon steels but also in alloy steels. Amongst the castings made in steel may be included oil-engine cylinders, high-pressure turbine casings, high-pressure valves of large size, numerous small castings in the motor-car industry, dynamo frames, hydraulic cylinders, tramcar bogie-frames, numerous castings used in locomotive construction and for rolling stock, and new applications for steel castings are continually arising.

Carbon Steel Castings.

The kind of steel castings more commonly referred to usually consist of steels possessing a carbon content up to about 0·5%, but averaging 0·275%. Although steels used in the production of castings are low in carbon, and in the wider sense are referred to as being mild, they are divided by the foundryman into grades. But it must be distinctly understood that this grading of soft, medium, and hard steel concerns only steels having carbon content up to about 0·5%, and is only applied as a relative comparison between steels suitable for different types of castings. Thus a soft steel may contain up to 0·25% of carbon, a medium steel 0·35%, whereas a steel having a carbon content of 0·5% is hard by comparison. The use of the soft steel for castings is undoubtedly due to its greater resistance to shock without fracture. Whereas a hard steel will fracture under exceptional stress, a soft steel is more likely to buckle, and, consequently, for many types of castings, it is more reliable. Usually, however, the softer the steel—that is, the lower the carbon content in the steel—the more difficult it is to produce sound castings. The carbon contents of the steel, besides influencing its mechanical properties, also affect the melting temperature; the lower the percentage of carbon in the composition the higher the melting point.

Alloy Steel Castings.

During more recent years considerable attention has been given to the need for special kinds of steel to cope with the exacting demands of modern engineering. Much valuable research work has been done in the production of steels to meet special needs, in which elements other than carbon are the predominating factors in determining the particular properties of the steel. These are known as alloy steels. Various elements such as nickel, chrome, manganese, molybdenum, vanadium, etc., may be associated with the steel to produce special characteristics in the alloy, the proper application of which will increase physical properties, such as tensile strength, elastic limit, resistance to impact, resistance to abrasion, and resistance to oxidation, that could not be obtained from the best of carbon-steel castings. The great strength of alloy steels is being utilised for reducing the size and weight of integral parts, thereby eliminating much of the bulk and weight of the final assemblies, with the added advantage of much uniformity.

The characteristics of alloy steels are many and varied, but, broadly, there are three distinct classes, and their lines of demarcation are clearly marked. Thus, for instance, there are the steels of high physical properties, such as tensile strength, ductility, resistance to impact, abrasion,

distortion, and fatigue; then there are those steels with extraordinary properties such as resistance to corrosion and magnetic permeability; and the growing application of heat-resisting alloys entitles them to recognition among the alloy steels.

Manganese Steels.

The first of the alloy steels, both in conception and application, are the manganese steels. Although these steels are familiar, it is doubtful whether their development and application to machinery are fully appreciated. As these steels have remarkable resistance to abrasive wear, extreme toughness and hardness combined with ability to absorb severe shocks and impacts, they are used extensively for parts of machinery that are subjected to extreme wear and abrasion, where durability is of prime importance. Manganese-steel castings, in which the manganese content varies between 11 and 13·5%, with from 1 to 1·3% carbon, are used for a great variety of purposes, including parts for steam shovels, crushers, dredgers, grab buckets, rolling-mill machinery, kilns, brick and tile machinery, coal mining and breaking down machinery, copper converters, concrete mixers, travelling cranes, lifting magnets, ball mills and gears. Manganese, steel is also used in the manufacture of safes, railway frogs and crossings, foundry tumbling barrels, and for much work of a similar character. Due to its extreme hardness, machining it was practically impossible, and grinding machines were necessary in giving the required finish to a casting. While grinding is still adopted in many instances, the recent developments in cutting materials have made possible the cutting of this extremely hard alloy.

Manganese steels of low manganese content, between 1 and 1·5%, were formerly considered to constitute a good grade of converter steel, but as a result of heat-treatment these steels have proved to have excellent tensile strength and ductility, with very good resistance to abrasion, and during recent years these low-manganese-content steels have been included in the alloy steels. They have been extensively cast into caterpillar shoes, wagon wheels, and are used for many castings requiring high physical properties at relatively low cost.

Alloy steels containing nickel or molybdenum with manganese somewhat higher than normal deserve to have a wider acquaintance among manufacturers of steel castings. Nickel-manganese steel usually contains about 1% nickel with 1 to 1·5% manganese, while the carbon contents usually range between 0·30 and 0·40%. The use of nickel obviously adds to its cost, but the increase in ductility and toughness amply justifies it. This metal also has a higher Brinell hardness than the straight manganese steel of low content under similar heat-treatments. It is used for substantially the same class of castings as the 1 to 1·5% manganese steel. In the manganese-molybdenum steels the manganese is kept within the same limits, with molybdenum ranging between 0·20 and 0·40%. The results, as a whole, are the same as with nickel-manganese steel, except that the elastic ratio is raised somewhat.

Nickel Steels.

The addition of nickel to steel in the formation of nickel steel produces a steel of greater ductility and elasticity than a carbon steel of equal strength. Nickel steels are probably the oldest of the alloy steels, and were developed primarily for use in the production of armour plate. The nickel contents cover a wide range from 0·50 to 5·0%, with carbon varying between 0·10 to 0·60%.

The characteristics of nickel steels are high tensile strength and elastic limit, with very good ductility, fine-grained structure, and, usually, freedom from blow holes and porosity. These steels are used where extreme toughness is the outstanding requirement. The lower carbon content nickel steels are invaluable for parts that are to be casehardened. Their use results in a very tough core, with a hard case, which is the ideal condition. Bridge castings, rail clamps, etc., are indicative of numerous uses for which straight nickel steels are applicable. The alloys of high-nickel content are not used much by the foundryman, but they offer distinct possibilities. They have abnormal magnetic constants.

Chromium Steels.

Chromium steels of low chromium contents have been cast but their use is uncommon. The chromium gives more hardness than carbon at the expense of reduced ductility. The chromium contents of these alloys range between 0·60 and 1·50%, with carbon usually varying between 0·15 to over 1·0%. These alloy steels, particularly those containing the higher carbon, are used where rigidity and freedom from distortion are the predominating requirements.

The high chromium steels which constitute the stainless steels usually have a minimum chromium content of 12%, while in some the percentage is much higher. Those having very low carbon contents are frequently referred to as stainless irons, but they are all made by the same process and may be referred to as alloy steels, although heat-treatment is necessary with stainless steels, while it is not required to bring out stainless properties in the very low carbon alloys. High-chromium alloys have been used considerably during recent years for castings incorporated in equipment used in the cracking of crude petroleum oils, which have a corrosive action at high temperatures due to a high sulphur content. These alloys have also been used in castings for food-handling machinery, both to free the food from contamination and to increase the life of the equipment. The chemical industries have been using increasing quantities in view of the fact that ordinary steel castings have a very limited period of usefulness in the handling of acids and caustic alkalis. Thus for agitator arms, kettles, pipe lines, driers, and other parts subject to corrosive influences, these alloys are finding an increasing usefulness.

Nickel-Chromium Steels.

The alloy steels which form the nickel-chrome series constitute a very large and comprehensive range. They are the most widely used of the alloy steels. The hardness imparted by the chromium coupled with the toughness and high elastic limit imparted by the nickel gives a steel which is satisfactory for many purposes. They form an ideal combination, having unusually high strength, very good ductility, and a remarkable resistance to fatigue and abrasive wear. The nickel content ranges between 0·50 and 3·5%, and the chromium from 0·45 to 1·75%, with carbon from 0·10 to 0·60%. What is considered to be the ideal combination is a ratio of nickel to chromium of about 2 to 2·5 to 1. As with straight nickel steels, the nickel-chrome alloys with low carbon contents find application in castings that are subsequently casehardened, and, as a general rule, are more or less interchangeable with them but give a somewhat heavier and harder case. The medium carbon steels have the widest application and the greatest possibilities. Where abrasive wear is encountered they are probably supreme. They are used extensively for caterpillar shoes, chain belt, rolling-mill rolls, excavating buckets' lips and teeth, oil-well machinery, hoisting drums, brake drums, special track-work, lightweight car wheels; in fact, for anything where wear is due to abrasion and not to impact. Actual service tests apparently indicate that in regard to abrasive qualities these steels are superior to others that are much harder. Toughness is increased by increasing the alloying contents and allowing the carbon to drop to about 0·30. This metal is very useful for high-pressure valves and fittings and for railway knuckles.

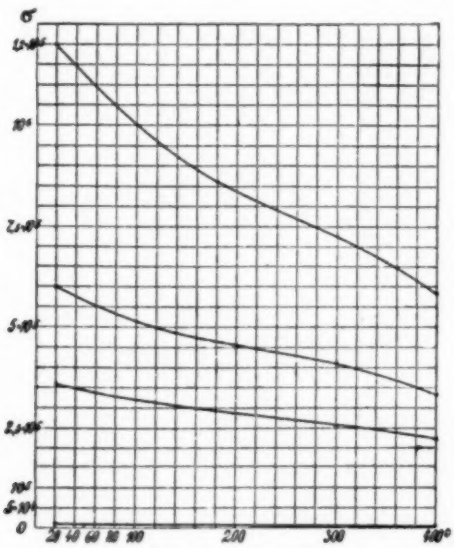
The high nickel-chromium alloys constitute what are known as the heat-resisting steels. The ranges of alloying elements are very wide, the nickel varying from 20 to 70%, while the chromium varies from 10 to 40%. The carbon

(*Continued on page* 155.)

The Development and Application of Non-Metallic Electric Heating Elements

By a Special Contributor.

THE production of resistances for electric heating has involved much research work, and experimental investigations were in progress for many years with the object of overcoming difficulties which at one time were considered inseparable characteristics of refractory materials. The need for a commercial material capable of maintaining a similar resistance against the influence of atmospheric air under high temperatures, as precious metals, was long apparent. In addition to heat-resisting qualities and resistance against chemical agencies, a high and variable specific resistance is necessary to enable the heating bodies to accommodate themselves readily to various line tensions and apparatus.

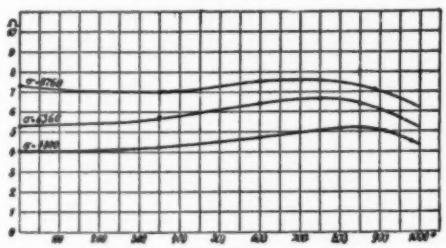


Temperature in Deg. C.

Fig. 1. Alteration of the specific resistance under temperatures ranging up to 400° C.

The development in the production of a non-metallic resistance material which would comply with all reasonable requirements is the result of various scientific investigations and consisted primarily of silicon carbide. Many unsatisfactory results obtained from attempts to provide a suitable material were found to be due to unsuitable binding material, or binding methods. The first step to the solution of the problem was made by mixing free silicon with silicon carbide. These must be mixed as thoroughly as possible and given the desired form – for which purpose a volatile or carbonisable material may be used, - and then heated until the silicon is softened, so that the substance will be fritted to a dense body. If a carbonisable binding material is used the carbon given off will combine with the silicon to form silicon carbide. The resistances manufactured by this process gradually change their electrical resistance under constant glowing temperatures, owing to the influence of the nitrogen in the air.

A further advance was made in commencing to burn the form in silicon carbide and silicon in an atmosphere containing nitrogen, whereby nitrogen was absorbed by the metallic silicon under the formation of silicon-nitrogen, which bind the silicon carbide and form extremely dense, firm bodies. But these do not entirely fulfil the requirements expected from electric heating bodies: even these modify their resistance under constant glowing temperatures, although very gradually. Further investigations, however, have succeeded in removing this drawback by thoroughly



Temperature in Deg. C.

Fig. 2. Condition of tubes, with positive temperature coefficient of 700° to 900° C.

mixing silicon carbide, silicon, and carbon together, pressing these into forms, and then exposing them to the action of carbon monoxide at a temperature of about 1,500° C. The metallic silicon absorbs carbon monoxide, forming silicon oxide of carbide which, like the nitrogen compounds of silicon, binds the substance, making extremely dense, firm bodies. If subjected to a greater head of 1,600° to 1,700°, the free carbon in the forms will reduce the silicon oxide of carbide. This newly formed silicon carbide will bind the silicon carbide already present in the substance to firm bodies consisting entirely of silicon carbide, if the mixture has been properly selected. In this way electric conducting bodies have been produced which combine the valuable attributes which an electric heating body must embrace, viz., high refractory qualities, great

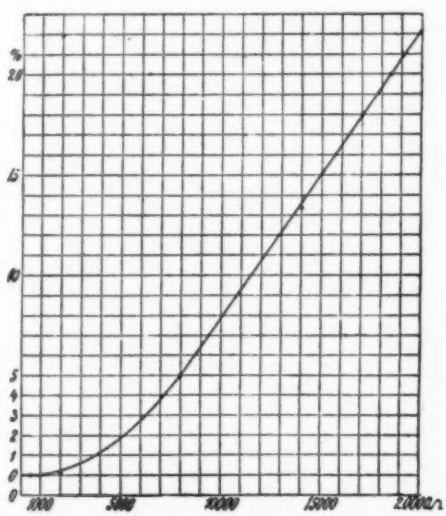


Fig. 3. Resistance alteration of tubes in percentage with 500 to 20,000 ohms when moistened with water.

resistance to the influence of the atmosphere, and high variable specific resistance. They are available in various forms in silicon carbide and are manufactured in a number of grades depending upon the process of manufacture

adopted, which are suitable for varying purposes. Thus one grade is suitable as an electric resistance material for permanent loads under glowing temperature and for high momentary loads. The next grade is suitable as electric heating resistances for temperatures ranging up to about 1,400° C., while another grade is suitable as a fireproof material which will withstand violent changes in temperatures.

In the first grade referred to the material consists chiefly of silicon carbide and silicon, or the nitrogen and carbon-monoxide compounds of silicon. The high ohmic resistances are supplemented by suitable non-conductors, the resistance bodies being made in the form of round and rectangular bars, tubes, rings, etc. The specific resistance of one type of this grade applied to a square centimetre cross section and one metre length, can be modified almost without limit from 100 ohms upwards by various methods of manufacture and by the selection of the mixtures. As a result of experiments with this type, it has been conclusively shown that the electric resistance temperature coefficient is negative, and that this increases by ordinary temperature with the height of the specific resistance.

Assuming that the resistance at a normal temperature varies from $\sigma = 1{,}000$ to $\sigma = 10 \cdot 10^6$, the resistance will decrease at

100° C. by 5 to 17%
200° C. by 10 to 25%
300° C. by 18 to 45%
400° C. by 25 to 60%

as shown in the graph, Fig. 1. An exception will be found in a small group, the specific resistance of which varies from 5,000 to 10,000 ohms, and the temperature coefficient of which, as will be seen in Fig. 2, is positive up to 900°.

The influence of moisture on the material itself is negligible, but while it will impair the electrical resistance of silit bodies with a low ohmic resistance little or not at all, it will impair those with a higher ohmic resistance in proportion to the height of the specific resistance. Experiments have been made with tubes which have been submerged in water for a few minutes and then superficially dried, and these have shown that tubes with a resistance of 1,000 ohms do not alter their resistance, as shown in Fig. 3, but a reduction in resistance was found in those with a resistance of

5,000 ohms of about 2%
10,000 ohms of about 8%
20,000 ohms of about 22%

The reduction in resistance, due to the moisture, can be prevented by suitable impregnation.

The electric strength depends on the form of the resistances, the duration of the load, the specific resistance, and

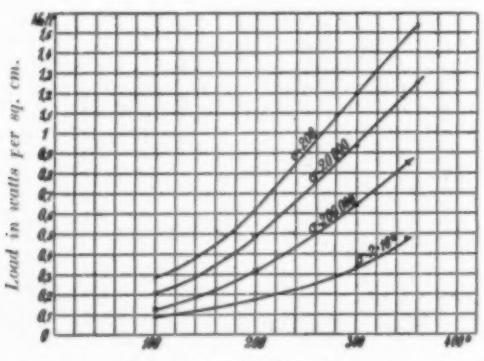


Fig. 4. Permanent loads of resistance of 200 to 2,000,000 at temperatures of 100 to 350° C.

on the permissible temperature. With a constant load the specific load will be greater the lower the specific resistance and the higher the permissible temperature, as will be noticed in Table I. The influence of the specific resistance on the height of the load at various temperatures is shown in the graph Fig. 4.

For temporary stresses the resistance rods can be loaded considerably higher and to a greater extent, as will be noted in Table II, the lower the specific resistance of the material, or, the lower the electrical resistance temperature coefficient the shorter the duration of the load, providing

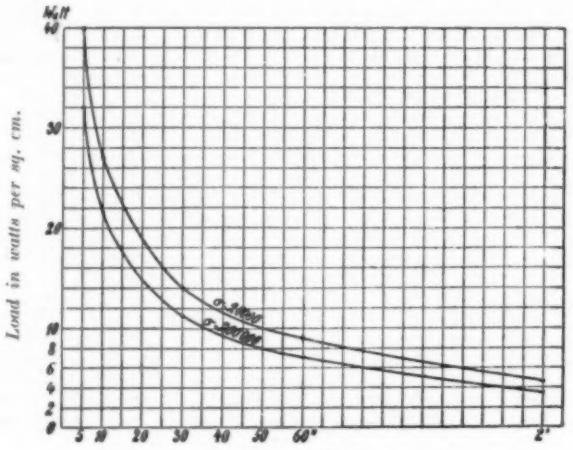


Fig. 5. Momentary loading of resistances of −20,000 to −200,000 at an end temperature of about 300° C.

that the succession of loads is so arranged that the resistances can cool to a certain extent. The curves shown in Fig. 5 demonstrate the results given in Table II.

PROPERTIES OF RESISTANCES KNOWN AS SILIT.

	Breaking Stress Kg./Sq. Cm.	Specific Weight.	Weight of Cub. Cm.	Average Specific Heat.
Class I.	400 to 800	2·26 to 2·83	2·10 to 2·25	0·18
Class II.	100 to 200	2·96	2·15	0·17
Class III.	800 to 1,200	2·67 to 2·83	2·20	0·19

Non-metallic resistances of this grade have a very wide usefulness for varied purposes, and are now being used as resistances for lightning conductors, excess voltage cut-outs, protection switches; series, regulating, and starter resistances are also made in various forms.

The valuable quality of the second grade of these resistances of not altering under high glowing temperatures

TABLE I.

Specific Resistance of Rod.	Load in watts per sq. cm. at a constant load and a temperature of the resistance of ° C.			
	100°	200°	300°	350°
200	0·29	0·62	120	1·54
20,000	0·21	0·48	0·95	1·25
200,000	0·13	0·32	0·64	0·85
2,000,000	0·09	0·17	0·33	0·74

makes them peculiarly suitable for electric heating. They are employed for this purpose in the form of bars and tubes of various diameters, and in length ranging up to 1,200 m.m. The specific resistance of this grade may vary from 200 to 20,000 ohms. The electric resistance temperature coefficient is negative, increasing, as will be noted in Fig. 6, with the magnitude of the specific resistance at a normal temperature. It is interesting to note that although the resistance drop at 1,200° C. amounts to about 50% on heating bars with a resistance of 4,000 ohms, it will only

be about 32% on heating bars with a resistance of 400 ohms, while from 900 to 1,000° C. the resistance will hardly alter at all, a property which is of extreme importance in the use of silit for heating purposes. The electric load

TABLE II.

Specific Resistance of Rod.	Load in watts per sq. cm. surface up to an end temperature of about 300° C. during				
	5 secs.	10 secs.	30 secs.	1 min.	2 mins.
20,000	40	27	14	9	4·6
200,000	32	21·6	11·3	7	3·5

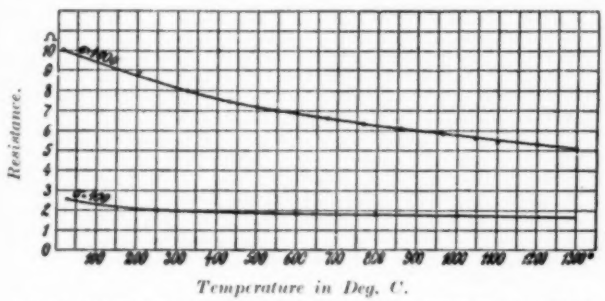


Fig. 6. Alteration of specific resistance at temperatures of 1,300° C.

efficiency of these bodies of varying diameters, at temperatures ranging from 400 to 1,200° C., is summarised in Table III. If the data of the specific load of the heating bodies, in varying diameters, are reproduced in diagram, the curves shown in Figs. 7 and 8 will result, from which the specific load for the respective heating bodies can be read at all temperatures lying between 400° and 1,200° C.

On all electric heating bodies the nature of the current feed will exercise a very great influence on the life of the

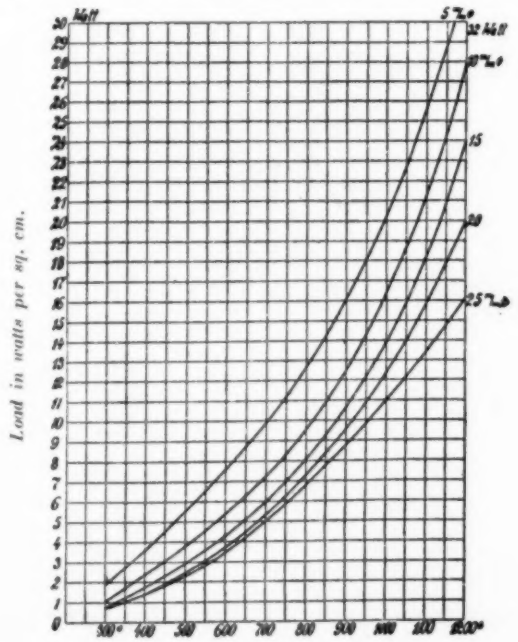


Fig. 7. Watt reading per square centimetre surface at 400 1200° C. in the open air for tubes of 5 to 25 mm. diameter.

resistances. Special care must be taken to obtain the best possible conductive contact ends, in order to avoid intermediate resistances. It is also equally important that the heating resistance can expand without hindrance. According to investigations of Dr. Egly, the linear expansion of one type of resistance in this class amounts to

About 0·10% at 400° C.
About 0·38% at 800° C.
About 0·66% at 1,200° C.

Homogeneous silver plating will supply good conducting contacts, but the silver-plated ends should be wound round with silver-plated iron wire to obviate the immediate resistance. These are effective for glowing temperatures below the melting point of silver, but for high glowing temperatures the contacts would very soon be destroyed. This difficulty is surmounted in a very practical manner by smelting a glaze of boracic acid or borate on the points adjoining the glowing parts of the heating body. In this way the silver becomes incorporated with the heating body, and gives an extremely good electric conductive efficiency and good heating conductivity at this prepared point. Further protection of the contact ends can be secured by fitting cooling heads, which consist of a metallic cement of good heat-conducting properties.

TABLE III.

Diameter of Heating Tube in Mm.	Load in watts per sq. cm. surface under a permanent load at a temperature in Deg. C.				
	400°	600°	800°	1,000°	1,200°
5	3·6	7·6	12·6	20·3	33
10	2·3	5·3	9·5	16·4	28
15	1·6	4·2	8·0	13·8	24
20	1·4	3·7	7·3	12·3	20
25	1·3	3·4	6·7	11·0	16·1

These non-metallic heating bodies have a wide range of usefulness, and are particularly suitable for carburising and general heat-treatment, non-ferrous metal melting, tube, plate reheating, and wire-patenting furnaces, sheet normalising furnaces, and enamelling ovens. Their value is greatly enhanced by the fact that they can easily be worked mechanically, as they are readily filed, drilled, and sawn.

The further grade of resistance bodies, apart from their use as electric conductors, serve as fireproof bodies. They are manufactured in the form of tubes of varying diameters, and in lengths ranging up to 2 metres. The linear expansion amounts to about 0·3% to 0·6% at 700° to 1,400° C.

On account of their powers of resistance to violent changes in temperature their good heat-conducting properties and their imperviousness to gases, these bodies have found great favour as protecting covers for pyrometers. As such they are used as tubes, closed at one end, into which standard pyrometers, consisting of porcelain double tubes and thermo-elements are inserted. Protected in this manner, pyrometers can be exposed to sudden temperatures up to 1,500° C. without being damaged, because the silit protection, although it transmits the heat fairly rapidly to the thermo-element, does not do so sufficiently quickly to crack the porcelain tube.

The successful use of silicon carbide material for varying purposes justifies the expectation that further applications will continually arise not only in electrotechnics, but also in other industries.

Progress of Ford Works at Dagenham.

(*Continued from page* 120.)

grading the coke produced in the coke ovens. The coal-handling plant will be one of the finest installations of its kind, as its operation will be almost entirely automatic.

On one side of the coke ovens the by-product plant will be installed for treating the liquid residues produced in the coke ovens. These residues consist of the different raw products of condensation, from which various tar derivatives, as well as benzol, are produced.

Some Remarks on Furnace Designs and Plant Layout

By Walter Lister.

The primary requirement in furnace design is the concentration of the available heat on the charge.

THE ideal furnace is one that will melt a charge quickly without melting the furnace at the same time. Given sufficient gas almost any furnace will melt quickly for a short time, but a sufficient supply of gas to achieve this often means that very soon there is no furnace left to melt anything in. Furnaces should be so designed that all the heat of the gas is concentrated on the charge, and not on the furnace linings. To get this result

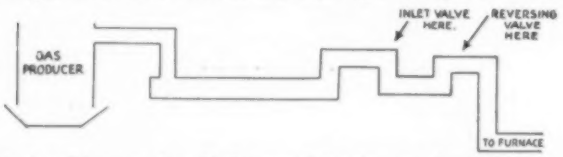


Fig. 1.—Diagram of an Underground Gas Layout, showing the large amount of obstruction offered to the passage of the gas.

the gas should come at as great a pressure as possible, and at a sufficient inclination. To obtain the greatest pressure possible there should be the least possible resistance to the passage of the gas from the producers to the furnaces; but in some lay-outs the gas has to surmount so many

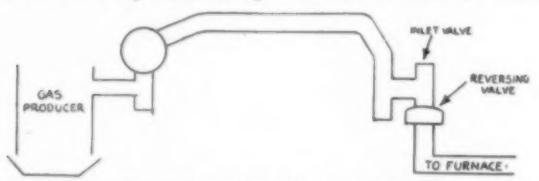


Fig. 2.—Less Obstruction offered by an Overhead Gas System.

obstacles that it eventually arrives at the furnace in a very exhausted condition. Fig. 1 will give some idea of the large amount of obstruction offered by an ordinary underground system.

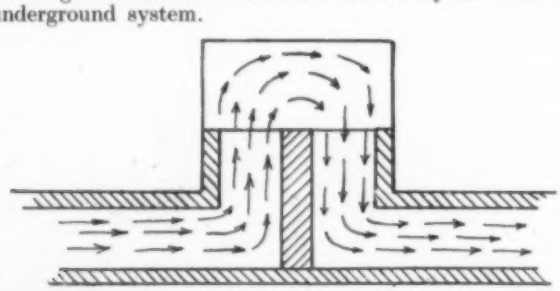


Fig. 3.—Diagram showing the large amount of obstruction offered to the passage of the Gas by a Valve of ordinary type.

It will be seen that there are many right-angled corners and high jumps for the gas to negotiate, and there are others not shown in the diagram. The consequence is that when the gas at last arrives at the furnace its speed is lower than it would be with a straight passage.

An overhead system of gas carriage offers less obstruction, as will be seen from Fig. 2. Here there are very few right-angled corners and no "jumps."

As a set-off against the reduced obstruction offered is the loss of heat by radiation, but this can be reduced to a minimum by insulating the tubes between the plates and the fireclay brick lining with a course of Silocel bricks. These bricks are made from diatomaceous earth and have a very low heat conductivity. Insulating the gas tubes in this manner will save an appreciable amount on the gas bill.

The next item to be considered is the type of gas valve that will offer the least resistance. In many valves the gas has to climb a brick wall about 8 ft. high, somewhat in the manner shown in Fig. 3. Having surmounted this obstacle it has to drop down the other side and skid round a corner before it reaches the bottom of the regenerator. A lot of this sort of thing can be avoided by installing valves of the straight-through type, as shown in Fig. 4.

As will be seen from the sketch, these valves can be very simply constructed and made applicable to either air or gas. They consist of a machined water-cooled damper, working on a machined water-cooled seat, which is fixed at a slight inclination from the vertical so that the damper rests lightly on the seat, thus making a tight joint.

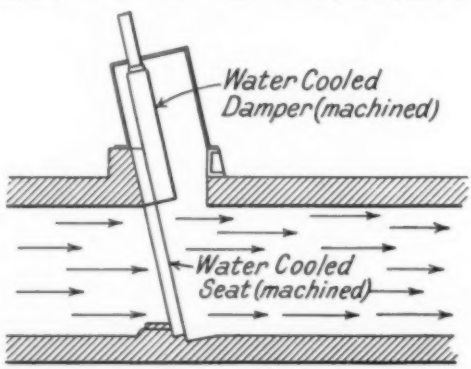


Fig. 4.—A Straight-through Valve offering less obstruction to the passage of the Gas.

The advantages of this type of valve are many, a few of which may be enumerated as follows:—

1. Increased efficiency of the furnace, due to unrestricted flow of gases through the valve.
2. Less steam pressure required at the gas producers, owing to less resistance offered by the valve.
3. Absence of open water seals, thereby less steam in the gas.
4. Minimum loss of heat in water cooling.
5. Adaptability to any desired flue arrangement.
6. Independent regulation of gas to and from the chamber.
7. Low upkeep cost.
8. Small floor space required in the valve pit.
9. No loss of heat through radiation from the valve.

An arrangement of a straight-through reversing valve system is shown in the sketch, Fig. 5.

The design of the furnace ports by which the gas enters, after passing through the regenerating chamber, may be considered after the valves. In some designs these are made very narrow, in order to obtain a high velocity of air and gas as it enters the furnace. While this may be a

success at one end, it is often a dismal failure at the other, because the narrow ports are unable to deal with the products of combustion, which have a larger volume than the incoming gas and air. The result is that flames blow out at the doors, as happens when a furnace is almost finished. To try to overcome this chimneys are made abnormally high, but even this is not a success. The cure is in increased gas pressure by removing all obstruction possible. The chimney should not be expected to overcome the evil of draught-impeding valves and narrow gas ports. The function of the chimney is to draw the waste gases from

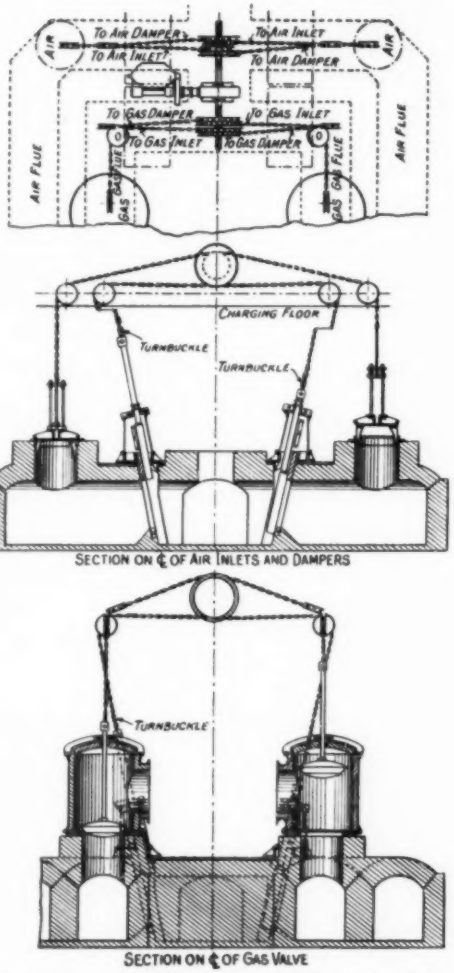


Fig. 5.—Arrangement of Bla-Knox Straight-through Reversing Valves.

the furnace, and not to draw the live gas into the furnace.

For furnaces of 50 tons or over, chimneys of 5 ft. 6 in. to 6 ft. diameter at the base and 150 ft. to 160 ft. high should be ample; there is no need to build them of larger size.

Some gas ports are designed with a very sharp inclination, so that the gas may be said to tumble headlong into the furnace in an endeavour to make up by force of gravity what it lacks in pressure. This is only a poor subterfuge and should not have to be resorted to. Moreover, ports of this description are generally of the blind variety; that is, it is impossible to see down them from the wicket, in order to level-up the port ends from inside, when necessary. In Fig. 6, sketch A, shows a design of port down which it is impossible to see, while sketch B shows a design which gives a clear view of the whole length of the port, enabling the ends to be repaired from the inside.

In furnace design the various types of port are legion. In my own experience I have tried all sorts—round, square, oblong, Mertz, McKune, etc.; but for all-round efficiency I have found nothing to beat the old type for fixed furnaces, that is, one air port extending almost the whole width of the furnace, with one gas port below, as illustrated in Fig. 7. The area of air inlet to gas inlet should be roughly 2 to 1. Water-cooled ports are a distinct advantage if properly installed, but if, as happens in many cases, the engineering is faulty they may become a great nuisance. But this does not alter the fact that if water-cooled ports of the right type are installed in a proper manner and carefully attended to the furnace will have a much longer life, as while the ports remain good other parts of the furnace can be easily repaired at week-ends, while if the ports are bad the furnace has to be shut down to effect repairs.

In tilting furnaces, or fixed furnaces fitted with movable blocks, the question of being able to see down them from the back does not apply. The only thing about movable blocks that requires any particular mention is the fact that

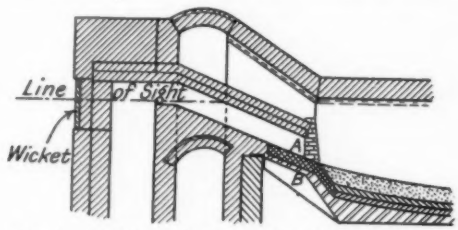


Fig. 6.—(A) A Blind Port, down which it is impossible to see from the Wicket in order to effect Repairs.

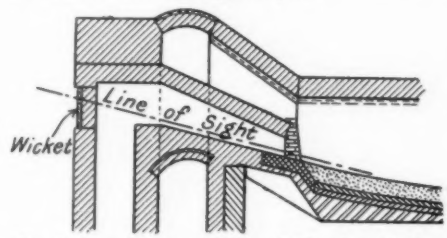


Fig. 6.—(B). A better Design of Port. A Shovel can be inserted from the Wicket, and the Port ends levelled up.

a lot of money can be saved (as regards cost of repairs) by having them made in two sections, an outer and an inner section. The inner section is the one nearest the furnace, and when the port ends need repair this can be lifted out bodily by the crane and taken away for repairs, while a new one is put in its place. This avoids the necessity of removing the whole block. All chills should be water cooled, and pipes should also be run through the brickwork separating the air from the gas port, as shown in the illustration, Fig. 8.

In designing tilting furnaces a common fault is to allow for too much depth of bath in making the shell. When the usual thickness of hearth is put in it is often found that the furnace will not empty itself, and anything up to 10 tons or so of steel may be left in after the furnace has been tilted to its utmost limit. The only remedy for this is to raise the hearth accordingly, but this, of course, reduces the furnace capacity. Moreover, a hearth of abnormal thickness is always much more difficult to keep in good condition than one of normal dimensions.

The Regenerators.—The design of these to my mind is very important. Some builders, in order to save a few hundred bricks, build the gas and air chambers together, with only one dividing wall between the two. The consequence is that after a few years' service this wall becomes porous and gas filters through into the air chamber. When this happens a very short life can only be expected from uptakes and ports, and if the real reason is not discovered (which very often is the case) either the furnacemen or the brick manufacturers usually have a very thin time.

To avoid this both chambers should be built separately, each encased in their own jackets, with an air space

between. As regards size, chambers that are too small cannot make the best use of all the burnt gases and are liable to become choked very quickly, while chambers that are too large cannot be heated up to the required temperature. A good guide is to allow for about 100 cub. ft. chamber capacity at each end of the furnace for every ton furnace capacity, the air chambers to be about 25% larger than the gas chambers. But this does not apply

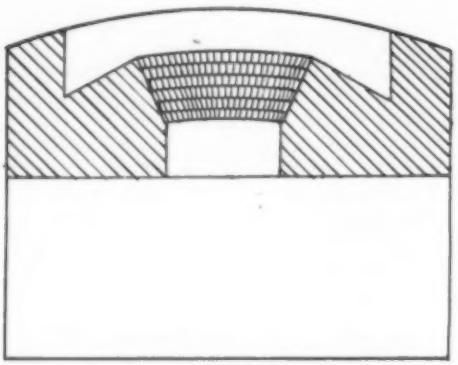


Fig. 7.—A useful type of Block.

to Talbot furnaces. A furnace of, say, 250 tons, working the Talbot process, need not have chambers any larger than would be necessary for a 50/60 ton fixed furnace. A 50-ton furnace should have about 21 courses of chequer work in each chamber. The top 14 courses should be semi-silica brick, and the remaining 7 courses at the bottom should be firebrick.

The efficiency of the chambers should be such as to leave the bottom courses at just a dull red heat.

The "Waste Heat."—There should be none. All modern lay-outs should include waste-heat boilers. There is always sufficient heat still left in the burnt gases, after leaving the furnace, to be usefully employed in raising steam for the gas producers. Here, again, an appreciable saving can be effected in the coal bill, an item well worth considering these days.

Electric Furnace Design.—The top-hole of perfection has not yet been reached as regards electric furnace design, especially in the construction of the larger sizes, say round about 30-ton capacity. These are usually designed for machine charging, and are generally equipped with one large door only. This has to serve for charging, slagging, and feeding. When the charge is melting down, it is very difficult, with this door only, to push unmelted scrap under the electrodes. The consequence is that there are pools of liquid at a high temperature under the electrodes, while around the banks the charge still remains unmelted. This portion of the charge only melts, after some considerable time, by radiation from the hotter parts under the electrodes. By the time the charge is all completely melted the furnace walls and roof have attained a temperature dangerously high. In fact, it is no uncommon experience to have the brickwork running before the charge is sufficiently melted to slag off. By the time the charge is hot enough to tap considerable damage is often done to the lining and roof. Under these conditions the furnace life is very short, and the cost of upkeep abnormally heavy. Linings and roof often require renewal after 20 charges, or less. One large door for all purposes is not sufficient. The electrode equipment should be so arranged that a small door can be fitted on either side in order to be able to shove unmelted scrap from the sides further towards the electrodes, and so prevent the heat localising in a small area.

Another way in which electric furnace design could be improved is in the angle of tilt on the slagging side. Most furnaces only tilt about 15° on that side, or even less. This is quite all right for slagging purposes, but when it comes to fettling the bottom after tapping the need is felt for a much greater angle of tilt in order to drain out pools of steel from under the electrodes on the further side. An angle of at least 25° should be arranged for on the slagging side.

The great drawback to the efficient and economical working of electric furnaces is the fact that it is very difficult, owing to smoke and fumes, to judge exactly what is going on inside. It is impossible to see clearly the roof and side walls, and consequently damage is only discovered after the furnace has been tapped. At the present time the only outlet for smoke and fumes is through the working door, and the workman who shovels coal and lime in has to exercise much agility in dodging the subsequent flames. In my opinion, the ideal electric furnace of the future will be one that will charge from the top by means of a movable roof. The electrodes will be inserted through the side walls, and will be pivoted so as to cover all parts of the hearth. When the charge is melted the electrodes will be withdrawn and the refining operation carried out on the induction principle. Roofs will be kept cool by means of a current of some non-combustible and non-oxidising gas; some arrangement will be made by means of which surplus gases will escape, and inserted at intervals in the lining will be windows of some transparent material as refractory as silica brick.

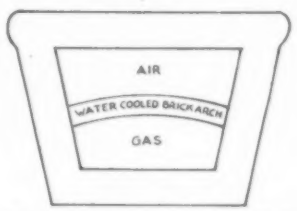


Fig. 8.—The Port End of a Talbot Furnace, showing the Water-cooled Brick Arch.

The British Acetylene Association.

THE report of the British Acetylene Association on the progress of oxy-acetylene welding and cutting in the British Empire is a very comprehensive one, and indicates the great strides this industry has made during recent years. This International Committee of Acetylene, Autogenous Welding and Allied Industries to all members represented on the Committee for information concerning the development of the industry during the past ten years. This report, together with the reports of other representatives, was presented at the Tenth International Acetylene Congress held at Zurich recently.

The opportunity has been taken to prepare a full and comprehensive report on technical training, applications in industry, and the general progress of the oxy-acetylene welding and metal-cutting processes in this country and in other parts of the British Empire. For convenience the report has been divided into three sections on which information was particularly requested. The first section appropriately deals with the facilities for training welders, without which the industry cannot make progress. The application of the oxy-acetylene process in industry is considered in the second section; some forty of the major industries coming under review in determining the manner and extent to which they employ it. In the third section the structure and operations of the oxy-acetylene trade is reviewed, and some consideration is given to the activities of manufacturers and suppliers of plant, equipment, and materials.

Quite apart from the excellent work of Mr. A. B. Harrower in collating and arranging the necessary information contained in this report, an outstanding feature is the indication it gives of a united effort, by all sections of the industry, for the continued expansion of oxy-acetylene processes within the Empire. The progress of electric welding, to which reference is made, seems to indicate that this industry is progressing at a more rapid rate than on the Continent.

The Application of Aluminium for Textile Machinery

By D. L. Pellatt.

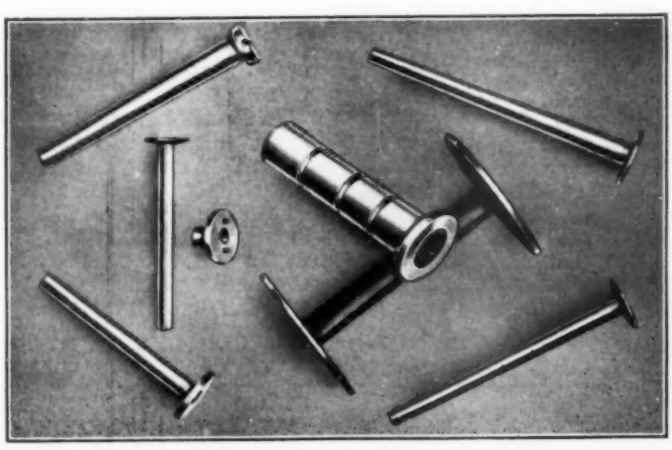
THE outstanding characteristic of aluminium is its low specific gravity, which, combined with its resistance to atmospheric corrosion and to certain types of chemical action, is causing a continued expansion in its production. In this expansion the textile machinery industries have naturally shared, and for certain requirements aluminium is proving specially suitable.

Its application for textile machinery depends upon one or more of the properties possessed by aluminium or its alloys of low specific gravity: adequate strength, resistance to corrosion, suitability for casting in sand or dies, and attractive appearance.

In contradiction to these properties upon which the use of aluminium generally depends is the limiting factor of relatively high cost.

In most cases aluminium for the production of textile machinery components usually replaces cast iron, and it is important that the relative costs of the two metals should be appreciated at the outset. The average cost of cast iron at the furnace mouth may be taken as approximately £5 per ton, while aluminium will be about £90 per ton. A comparison of the two metals must, however, be based upon their relative specific gravities, and as aluminium is about one-third the specific gravity of cast iron, the true cost comparison becomes £5 for cast iron and £30 for aluminium. A factor which must be taken into consideration, however, is the higher scrap value of aluminium as compared with cast iron. This helps to some extent to counteract the disadvantage caused by the higher initial cost of aluminium.

Alloys for Castings.—The selection of suitable alloys for the production of textile castings depends to a considerable extent upon the method of casting. Sand casting and gravity die casting, using permanent moulds, either with oil, sand, or steel cores, predominate. Pressure die casting requires special plant, and is not so suitable for textile machinery parts.



Considering the sand and gravity die-casting methods of the many alloys which are available, an aluminium-copper-zinc alloy containing 2·5—3% of copper, and 12·5—14·5% of zinc, and an aluminium-copper alloy, containing 6—8% of copper, may be taken as typical alloys suitable for sand castings. These alloys are easy to handle, have excellent casting properties, and are not high in price.

For gravity die casting, the alloys containing zinc are not recommended, but the copper series of alloys give quite satisfactory results when cast in permanent moulds. Silicon-aluminium alloys containing 11 or 13% of silicon are specially suitable. The latter may be modified to give an ultimate strength of about 11 tons per square inch. The silicon-aluminium alloys also possess the advantage of resisting corrosion better than any of the other common casting alloys.

The number of alloys that are available is very much greater than has been indicated above, and these all possess physical properties rendering them suitable for particular purposes. The alloy must, therefore, be selected with a view to the requirements of the finished casting, machining, and method of casting employed.

The field for textile castings is limited, and so far the use of the more modern alloys capable of giving high strengths with suitable heat-treatment have not received any general application. The use of gravity die castings is, however, increasing by reason of the fact that textile machinery is essentially a mass-production industry, lending itself to the economical production of castings in permanent moulds.

Types of Castings.—Suggestions have been made from time to time for the use of aluminium for most of the castings which are usually produced in cast iron. In most cases the saving in weight is stressed as giving lower freight charges and lower power consumption. To examine a particular instance, the use of aluminium driving pulleys in place of cast iron entails the use of a metal which would have a shorter life, due to the softer character of the metal. The grip of the driving belts would also be less definite, and in the case of a loose pulley the aluminium boss would require bushing to resist wear on the bearing surface.

It can definitely be stated that the reduction in weight alone does not justify the replacement of cast iron by aluminium. Reduction in weight must be allied to lowered production costs, as may be the case where gravity die castings are produced in permanent moulds by mass production methods, or some direct advantage in the operation of a machine by lowering the weight of some vital component. In the case of reciprocating parts, a saving in weight must mean a saving in power, even if this may be small. A definite distinction must, however, be drawn between reciprocating and revolving parts. In the case of the latter the reduction in weight cannot have any great effect on power consumption, as inertia is only overcome when the machine is started up. In the case of a reciprocating part, inertia must be overcome at each reversal. The difference in frictional losses during running caused by the extra weight of cast iron compared with aluminium is infinitesimal. It should be noted that in the case of reciprocating parts which are balanced, the saving in power is largely removed, but the reduction in weight is doubled.

Scrap Aluminium for Castings.—The fact that in most applications of aluminium for textile machinery this metal is substituted for cast iron, renders it very necessary that the extra cost should be reduced as far as possible.

This consideration has led to a considerable consumption of scrap aluminium. The use of scrap aluminium is sometimes regarded as undesirable because of the ease with

which aluminium oxidises on remelting. This view does not take account of the possibilities of modern melting plant or of all the factors involved. The economic employment of aluminium involves the scrap value of the metal, and where the requirements permit, the lowered cost of castings produced from aluminium scrap often allows it to be employed when the cost of virgin metal would render its use impossible.

While the use of scrap metal for the production of castings is somewhat difficult, given sufficient experience and suitable melting plant it is possible to maintain a high standard of efficiency. It is most desirable, however, that analytical control should be available, and that a suitable scrap should be selected. Under these conditions the only difference between melting virgin metal and aluminium scrap will be experienced in a slightly higher melting loss.

The strength which may be expected from castings produced from scrap materials is about 8 tons per square inch ultimate tensile strength, with a yield point of about 4 tons.

Another consideration in the use of aluminium is the problem of dealing with swarf from the machine shops. As it is no uncommon thing for nearly half the weight of small components to be returned from machining as swarf, the utilisation of this metal is of evident importance.

Remelting Swarf.—The economic recovery of aluminium swarf is often stated to be impossible, but experience shows that this problem is capable of solution provided that suitable plant is available. The plant usually employed for melting aluminium for casting purposes is not suitable. A furnace having a bath of relatively large dimensions is the only type which is capable of giving satisfactory results. The method employed consists in melting the largest swarf first and when a sufficient quantity is molten to add more swarf, pushing this right under the molten aluminium. This is continued until the bath of metal is nearly set, then the temperature is raised, the metal skimmed if necessary, and more swarf added. This is repeated until the bath is nearly full, when it is skimmed and the metal poured into ingots for remelting. It is advisable to leave a few inches of metal in the bath after pouring, so as to provide a bath into which to work the first batch of swarf for the next melt. A suitable furnace, dealing with turnings or borings of average character, is capable of a yield of remelted ingot representing at least 70 per cent. of the total weight of swarf charged.

Special treatment of the bath by painting with a thin paste of whitening in dilute silicate of soda assists in preventing attack on the iron by the molten aluminium.

Other Applications of Aluminium.

Although the most important use of aluminium for textile machinery is in the form of castings, its use is not confined to the different methods of producing castings.

Aluminium sheet, or pressings made from sheet, is suitable for covers where lightness combined with attractive appearance is desired. Bobbins and spools spun from aluminium sheet or tubing combine lightness with strength, and are of evident suitability.

Extruded sections and round bar also find application for a variety of purposes.

Aluminium for Rayon Machinery.—Passing to the application of aluminium for rayon manufacture, altogether fresh considerations emerge. The various commercial processes for the production of rayon are all essentially chemical processes. The properties which render aluminium a suitable material for these processes are, therefore, more akin to the use of aluminium in chemical industries than in other textile industries. The suitability of aluminium now depends upon its resistance to corrosion by water, soaping solutions, acids, etc., in addition to the properties already considered.

In all cases the resistance to corrosion by acids is highest in pure aluminium, while either pure aluminium or such alloys as duralumin, with a composition of copper (3·0—4·5%), magnesium (0·5—1·0%), manganese (0—0·7%), may be used for water, or, where high strengths are required together with resistance to corrosion.

The acids which aluminium is called upon to resist are: Nitric acid for nitro-cellulose rayon, acetic acid for cellulose acetate rayon, and dilute sulphuric acid for viscose rayon.

Storage Containers.

The first of these has now little commercial application, and need not be considered. Storage containers for the storage and transit of acetic acid may be suitably constructed in pure aluminium, and this metal may also be employed in conveying and handling the acid for the preparation of cellulose acetate. As, however, some 85% of world's rayon production is by the viscose process, the latter is naturally the most important in respect of the employment of aluminium.

The application of aluminium in this process falls into two divisions, the first being its use on the spinning machines, where the metal is used because of its relative resistance to sulphuric acid at a strength of 8 to 10%. The second use is in the finishing sections of the process, where the yarn is reeled, washed, and bleached. In the spinning-room aluminium is used for fume ducts and hoods, spools for bobbin spinning, and spinning pots for centrifugal spinning, as well as for traverse rails, covers, and various similar purposes.

The aluminium used may be formed by casting in sand or dies, as in the case of centrifugal pots, or in the form of sheet for covers, ducting, etc., or in the form of extruded sections, as for traverse rails, or alternately, the components may be formed in spun aluminium as for spinning bobbins, and sometimes for pots. In every case, however, the aluminium must be pure, and not an alloy.

The use of aluminium depends not only upon its relative resistance to acid attack, but also upon the fact that aluminium sulphate produced by the slow solution of the metal does not form a harmful compound, as would be the case if copper, for instance, passed into solution. As already indicated, the resistance of aluminium to sulphuric acid is only relative, and consequently its use must be dependent upon lack of a more suitable material.

In the case of spinning bobbins and pots, aluminium is now largely displaced by Bakelite, which is not only completely resistant to acid, but owing to the methods of production is cheaper than an aluminium pot protected from acid attack.

In the finishing sections of the viscose process the yarn is reeled into hanks on reels, the swifts of which must be as light as possible on account of the delicacy of the thread. The swifts must also be resistant to corrosion, and of suitable strength. The use of aluminium die castings is immediately indicated, and is in general use. In the next process the yarn is carried on poles of duralumin, or of similar alloy, through the washing machine, and the hanks may then be stretch-dried between poles of the same metal. Duralumin is used for this purpose on account of its strength and resistance to corrosion. In the bleaching section aluminium is employed for the driving ends of the skein rods and for such purposes as the heater batteries used for controlling the temperature of the final soaping solution with which the yarn is treated.

Aluminium for Metallising.—Mention must be made of the application of aluminium by means of spraying. This process is employed in the rayon industry for water storage vessels and containers, and in the textile industries generally for the protection of annealing pots, heat-treatment baths, etc., from the action of furnace gases.

Finally, aluminium is finding increasing employment in painting textile machinery and for metal ducting, etc., in textile factories. The use of this paint is extending rapidly on account of its light-reflective properties, and also on account of its durability.

Modern Practice in the Cold Rolling of Non-Ferrous Metals

By C. E. Davies, A M.I.Mech.E.

THE metals, excluding steel, which are regularly produced in strip or sheet form by cold rolling are: (*a*) Copper; copper-zinc alloys—*i.e.*, brass of various qualities; nickel alloys, such as nickel silver, cupro-nickel, etc.; aluminium and aluminium alloys; and zinc. (*b*) Gold and gold alloys; silver and silver alloys; and platinum. (*c*) Tin; lead; and tin-lead alloys.

Group (*a*) represents the bulk of the cold-rolled production, especially as regards copper and brass. Group (*b*) being precious metals are rolled only in comparatively small quantities, and the soft metals and alloys in the last group require somewhat specialised treatment.

Whilst the machinery and methods employed are in principle the same for all these metals and alloys, a study of representative practice is now confined to copper and brass, as these are produced in relatively large quantities; leaving aluminium (the cold rolling of which is already a large and growing industry), nickel alloys, and the softer metals in group (*c*) to a later special consideration. To limit the scope of these notes still further, the rolling of brass in its several varieties may be taken as illustrating cold-rolling practice in general. Copper is rolled in much the same way, as is also nickel silver and aluminium, requiring only modification in detail treatment, as required by the different physical properties of the individual metals.

Brass and copper are cold rolled into both strip and sheets; the former being roughly defined as being comparatively narrow and in long, continuous lengths, usually finished in coils, whereas sheets are rolled in considerable widths, and in lengths usually not more than two to four times their width.

As the modern tendency is to roll strip brass in greater widths, it is of interest to confine attention to strip rolling.

For very many years the practice of cold rolling brass strip remained stationary with little or no development, but during the last decade great advances have been made, tending to more economical production and a higher quality of product; and with the need for reducing cost of manufacture and improving finish and accuracy, there has arisen a demand for more efficient machinery, although it must be admitted the general class of machinery available at any period has been in advance of requirements of the metal trade at the time.

Prior to the war very little brass strip was rolled in this country in widths greater than 8 in., and the largest proportion of finished strip was from 0·040 in. to 0·010 in. thick (excepting the thicker metal for small arms and artillery cartridge cases). Roughly, the process was as follows:—

The cast ingot, about 1¼ in. thick, say 8 in. wide, 24 in. effective length, about 80 lb. weight after cutting off the runner, was first reduced in a breaking-down mill, with rolls 20 in. to 24 in. diameter, in a series of passes to about ⅝ in. thick.

At this stage annealing was necessary; after which further reductions to ¼ in., or less, was effected in "getting-down" mills with rolls somewhere about 15 in. diameter, the metal being rolled out in straight lengths and again annealed.

After this the practice would depend to some extent on the finished gauge required, but generally a series of "getting-ready" passes were taken, preparing the metal for final finishing in smaller rolls, which would vary from 12 in. to 8 in. diameter, depending on width.

The mills employed were comparatively crude machines, with rolls of chilled C.I., and the rolling speeds were very slow, as follows:—

	Rolling Speed.
Breaking-down mills	40 to 50 f.p.m.
Intermediate mills	50 to 60 ,,
Finishing mills.....	60 to 80 ,,

The above outline represents very roughly the general practice in England 15 to 20 years ago.

Continental practice had a great influence, firstly, in introducing the use of hardened-steel rolls, and in improving the design and workmanship of the rolling mill.

Hardened-steel rolls have come to be almost universally adopted in place of chilled C.I. rolls for all cold-rolling mills, excepting breaking-down mills and the heavier sheet mills, and even for these semi-hard steel rolls are becoming quite general.

The advantages of the hardened-steel roll are:—

(1) Greater strength and capacity for taking heavier reductions.

(2) Superior roll surface, giving better finish.

(3) Regrinding less frequent, and consequently longer life.

The improved workmanship and design of the Continental mills, as compared with the old-type mills which were introduced into this country some 20 years ago has created a demand for a higher-grade mill and has raised the standard of rolling-mill construction generally, as now the cold-rolling mill produced by makers in this country is a sound engineering job.

More recently American practice has been extensively studied to great advantage, and the modern British cold-rolling mill combines the advantages of the accurate workmanship of the Continental mill with the high productive capacity and the labour-saving devices which are the leading features of American mill design.

Roughly, the main developments obtained from American practice are higher rolling speeds, and more powerful mills capable of heavy reduction at high speeds.

In 1926 a study of representative practice in the States can be summarised as follows:—

(*a*) *Size of rolls*:—
Breaking-down mills, 20 in. to 24 in. diameter, usually 36-in. face.
Finishing chilled C.I. rolls, 20 in. × 36 in. diameter, also mills fitted with steel rolls, 10 in., 12 in., and 16 in. diameter.

(*b*) *Maximum width of strip rolled*. At this period the maximum width of strip usually rolled was 24 in.

(*c*) *Rolling speed*—

Breaking down	115 to 150 f.p.m.
Running down.....	175 to 250 ,,
Finishing	250 ,,

(*d*) *Power required*—

Breaking down	500 h.p. (one mill).
Running down.....	700 h.p. (two mills).
Finishing	350 to 400 h.p. (two mills).
Small mills for finishing narrow strip,	75 to 100 h.p.

It will be noted from the above that for intermediate and finishing work, generally, rolls of much larger size were used than those employed for the same work in England, and the rolling speed, as compared with those as previously given as representing older English practice, are very much higher, being roughly three times as great. On the other hand, the power provided was greater, due

partly to the increased speeds with heavy continuous working on large output, but also to rather inefficient design, especially as regards roll bearings and lubrication.

It is satisfactory to record here that present-day English practice shows a great improvement on the above, especially in regard to power consumption, as whilst working cold mills at equal or higher speeds, the power consumption is relatively lower.

The other point, namely, the rolling of wider strip, up to 24 in. wide, has also been taken up in this country and Europe; but generally, even to-day, 24 in. is practically the limit of width for brass rolled in strip form, and in England the more usual maximum width is from 12 in. to 14 in. wide.

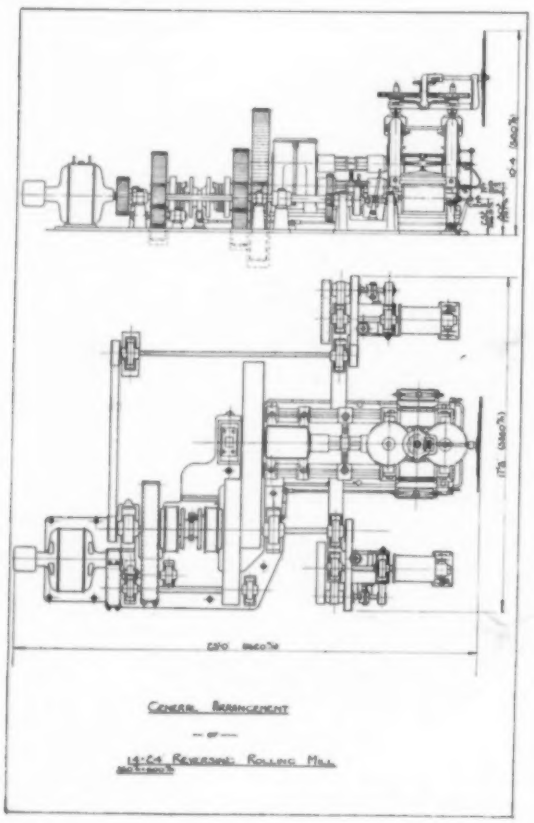


Fig 1.

The advantage of rolling in the greatest width possible is obvious, as the output of a mill in tons varies directly with the width, and it is consequently more economical to roll metal as wide as possible, in any case down to a certain point as regards thickness, after which it is sheared in a multiple-cutter gang slitting or shearing machine into widths as required by the buyer, and finished in narrower width to specified final gauge. Unfortunately, the difficulties in the way of satisfactory production of cold-rolled strip increase very considerably with increasing widths rolled. Apart from requiring heavier and more expensive mills, the greater distributed load on the rolls causes appreciable flexure of these, and renders it difficult to obtain flat strip uniform in thickness across the width.

On the Continent this difficulty has been attacked by providing a heavier "camber," or fullness, in diameter at the centre of the roll to counteract the deflection under load, using comparatively long steel rolls of small diameter. In America and England, whilst a certain amount of camber is provided, roll proportions are adopted to give greater stiffness.

Another inherent difficulty in rolling greater widths from metal which must be finally finished and supplied as narrower strip is the increased weight of ingot required. For example, if metal about 6 in. wide must be finished in continuous coils, 80 lb. in weight, and rolling is commenced on a width of 24 in., the ingot must be about 320 lb. in weight. The introduction of the electric melting furnace with water-cooled moulds has facilitated the production of such heavy ingots, and at the present time ingots 3 in. or 4 in. thick, weighing 600 lb., or even 1,000 lb., weight, are cast.

The breaking down of these heavy ingots presents difficulties, and it is necessary to adopt hot rolling where possible until the strip has been reduced to about $\frac{1}{4}$ in. thick. This method has been operated by several large Continental firms, particularly in Germany, and is being adopted in England. There are again difficulties in the way of hot rolling of brass. Firstly, many alloys can only be rolled hot with difficulty, and great care must be taken to ensure purity of the metals used. Secondly, hot rolling must of necessity be carried out at a high speed, with expensive rolling plant, and a very large output is obtained with continuous working; so large, in fact, that the output of a hot breaking-down mill can only be handled by the largest firms. It is probable therefore that whilst certain classes of brass may in future be hot rolled from the ingot, in the larger mills, a great deal of the metal will be still rolled cold in the breaking-down mill.

Another divergence in modern practice occurs in the next stage, that is in the intermediate rolling, where the reversing strip mill has been adopted in some cases, mainly in Germany; but in this country and America it has not been generally favoured, mainly as the speed is necessarily slow, and it is questionable whether the reversing mill has any very marked advantage from the point of view of economical working.

The general layout of a strip mill of the reversing type is shown by Fig. 1. In this the rolls are reversed by gearing and clutches, and coilers provided with adjustable brakes are installed on both sides of the mill, one acting as an unwinding drum, whilst the other in coiling, metal strip is brought to such a mill, and each coil is rolled backwards and forwards in a series of passes until annealing is necessary, or the required final thickness is obtained. The roll adjustment has therefore to be altered for each pass on every coil, and the process repeated for each succeeding coil; a certain loss of time is therefore unavoidable, as compared with the same work on a non-reversing mill where a large quantity of metal is rolled one pass at a time, with one setting of the rolls for each pass.

The foregoing notes give an outline of practice in rolling brass strip up to a few years ago, but during the last two or three years a very considerable development has taken place both in regard to practice in cold rolling and machinery employed, but even now there are in some respects differences of opinion, and it may be some time before a final decision is obtained on all points.

The object of all progress in this industry is increased production and reduction in manufacturing costs, also an improvement in quality of product; that is to say, superior finish and a higher degree of accuracy.

(To be continued.)

Refining Company's Interest in Mining.

The Mining Trust, Ltd., it is stated, have issued a statement to shareholders, signed by Mr. Leslie Urquhart, to the effect that arrangements have been concluded under which the American Smelting and Refining Co. has acquired a substantial interest in this company, and has provided the necessary capital for further development and equipment of Mount Isa on an extended scale, and also for the construction of a silver-lead bullion refinery. The American Smelting and Refining Co. has also agreed to place at the disposal of this company, for a minimum period of ten years, the benefit of the experience, assistance and advice of its technical staff.

Metropolitan-Vickers Electrical Co. Ltd., have opened new offices in Manchester, their address being:—Metropolitan-Vickers Electrical Co. Ltd., Ship Canal House, King Street, Manchester. Telephone Nos. City 6230/1/2. Telegraphic Address "Multiphase, Manchester."

Recent Developments in Tools and Equipment

A New High-Speed Lathe for Tungsten Carbide Tools.

SINTERED materials like tungsten carbide will remove metal at a much higher speed than the best high-speed steels, and in view of the increased stresses imposed upon the machine as a result of increased cutting speed the question of rigidity is a vital one. Developments in cutting materials have become a necessity in view of the progress made in the development of metals and alloys to withstand heavy and continuous service, and developments in machine-tool practice involving increased cutting power, whether by heavier cuts or by increasing the cutting speed, necessitates machines designed to bear the increased stresses to which they are subjected. These have been considered and adequately arranged for in the recently designed super high-speed lathe constructed by John Holroyd and Co., Ltd.

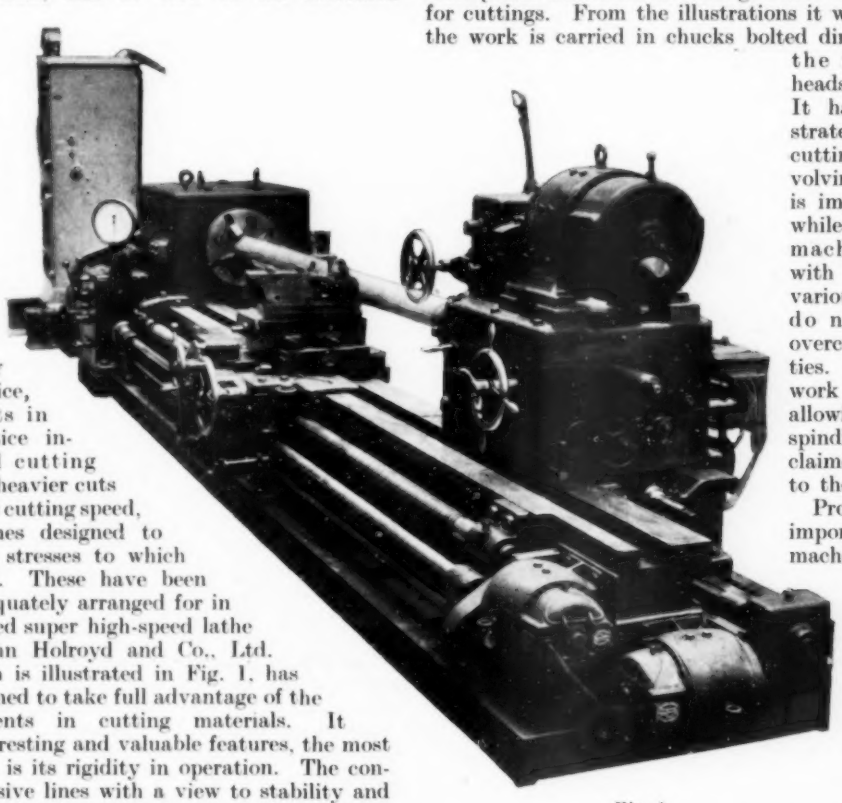


Fig. 1.

This lathe, which is illustrated in Fig. 1, has been specially designed to take full advantage of the modern developments in cutting materials. It possesses many interesting and valuable features, the most important of which is its rigidity in operation. The construction is on massive lines with a view to stability and the elimination of vibration when being used to remove the maximum amount of metal in the shortest time. The main casting forming the bed is a box type having a triple step form. It comprises a main gantry, extending to the main gantry. The front step is designed to support the saddle which is guided on the main gantry.

The loose head is adjustable on the auxiliary bed which is movable along the main bed by separate reversing motor. When fixed the rear step is covered by inclined steel plates which are so arranged that they form a chute for cuttings. From the illustrations it will be noted that the work is carried in chucks bolted direct to flanges of the fast and loose headstock spindles. It has been demonstrated that the heavy cutting of work revolving on dead centres is impracticable, and, while there are many machines operating with live centres of various designs, these do not adequately overcome the difficulties. Gripping the work in a chuck and allowing the loose head spindle to revolve is claimed as a solution to the problem.

Probably the most important part of a machine of this type is the saddle and also the tool support. Rigidity is of primary importance. In this lathe the saddle is carried on the main gantry and the front step of the bed. The design provides for adequate resistance to twist and to directions of thrust. Together with the slides, the saddle comprises a square turret, a swivel slide fitted

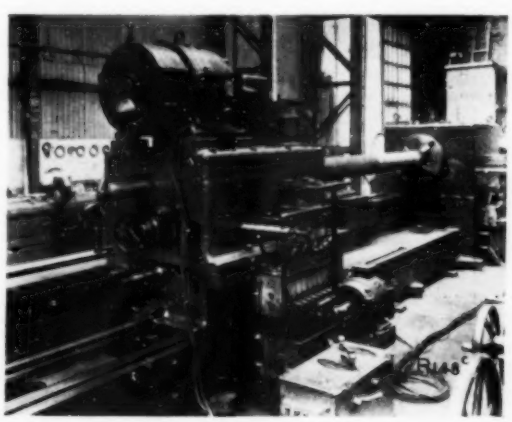


Fig. 2.

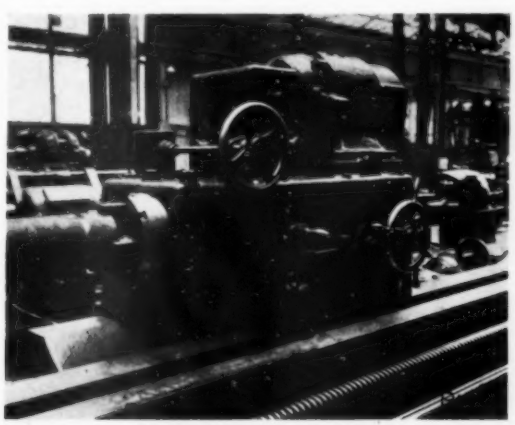


Fig. 3.

seating for the fixed headstock, together with a front and rear step. The rear step carries a short auxiliary bed to support the back surface of the loose headstock, as shown in Fig. 2, the front surface being supported and guided on with hand feed for turning short tapers and longitudinal cross feeds for sliding and surfacing or for cutting off, in addition to a quick power traverse along the bed. The latter is operated by separate reversing motor having a

push-button control. The turret and slides are so designed that when firmly clamped they form a structure of renarkable stability, the only moving slide being the one actually concerned in the operation. The method adopted ensures perfect rigidity, with consequent freedom from vibration.

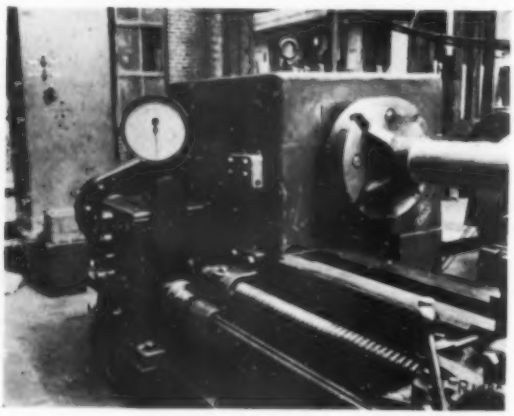
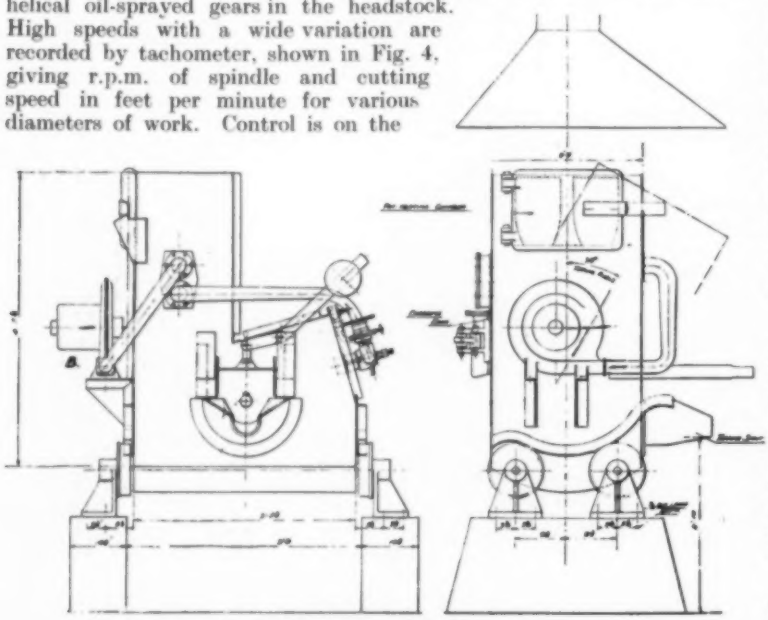


Fig. 4

The arrangement provides for the tool cutting "upside down" in a manner similar to a back tool; in this way the stress is applied direct to the saddle, which is rigidly supported, ensuring smooth and steady cutting.

The loose headstock can be arranged as a boring head, if desired, with separate motor drive, as in Figs. 2 and 3, and variable auto feeds, for such purposes as boring out ends of shafts, etc., whilst supported in a stay. In this design the boring spindle revolves in the opposite direction to the work, giving higher cutting speeds without revolving the work at high speeds in the stay. This machine is electrically driven and controlled on the "Ward Lennard" principle, the main 45-h.p. variable-speed motor being directly coupled to the spindle through one pair of double helical oil-sprayed gears in the headstock. High speeds with a wide variation are recorded by tachometer, shown in Fig. 4, giving r.p.m. of spindle and cutting speed in feet per minute for various diameters of work. Control is on the push-button principle and is centralised on the saddle.



An Oil-Fired Recuperative Furnace.

The lathe will turn to maximum diameter of 20 in. and will admit work up to 11 ft. long. The spindle speeds are variable between 66 and 400 r.p.m., while the sliding and surfacing feeds each have six changes. The whole machine occupies a floor space 34 ft. 6 in. by 6 ft. 0 in.

An Oil-Fired Recuperative Furnace, with Low Melting Costs.

THE primary need of the foundry industry to-day is reduction in production costs, with increased output, and one of the most important factors governing economic working is the melting plant employed. This is particularly true in non-ferrous foundries, where speed of melting, ratio of metal to fuel, melting losses, and control of composition have so much influence on production costs. In view of the progress gradually being made in the development of melting appliances, it is advisable that all interested in the melting of metals should investigate thoroughly the possibilities of new appliances which have for their object reduction in labour and fuel costs, rapid melting, and low metal losses. The recent introduction of the SKLENAR furnace is an instance of this kind. It is a tilting furnace, in which the charges are melted on the hearth by means of oil fuel. It is served with a PARWINAC burner, which in co-operation with a recuperative system effects considerable economies in fuel costs. Front and side elevations of a 300 lb. capacity furnace of this type are shown in the accompanying illustrations.

Although a recent development, the remarkable efficiency of this type of furnace is borne out by its extended use in many important engineering works. The results achieved in a comparatively short time definitely show advantages and economies over many existing methods of melting non-ferrous metals. As a result of long and exhaustive tests under actual working conditions, on the production of high-class castings, the loss in melting has been proved to be less than with crucible melting, and both physical and chemical tests have shown a superiority in quality of work produced. As an indication of the capacity of this furnace for a quick output, with comparatively low oil consumption, the results from a normal day's working have been taken as an example. Commencing with a cold furnace at 8-20 a.m., sixteen charges, each of 300 lb., had been melted and drawn by 6-10 p.m. The charges consisted mainly of copper scrap, ingots, and virgin metals for varying brass compositions, some charges were for casting copper flanges, while one charge was for a gunmetal composition. The average time of melting each 300 lb. charge, including the first melt, was 30 mins., with an oil consumption of 2·75 gals. With the cost of oil fuel approximately 3½d. per gallon, it will be appreciated that melting costs are low, and, even allowing for considerable delay in recharging, this furnace is apparently an economical proposition.

This furnace gives a working temperature up to 1,400° C., and, by means of the fine setting of the oil and air valves, close control of the furnace atmosphere is possible. Under normal conditions the furnace lining will last about six months, with intermittent patching when necessary. The lining consists of sectional numbered bricks, and the whole of the back plate of the furnace is removable, giving easy access to the interior and facilitating relining.

A fan, integral with the furnace, supplies the air, which is preheated by waste heat from the furnace before combining with the fuel through the burner. These patent furnaces are manufactured by British Reverberatory Furnaces, Ltd., in five standard sizes, from 300 lb. capacity to 2 tons; the smaller sizes up to ½ ton capacity are tilted by hand, while the 1 and 2 ton capacity furnaces have their tilting mechanism operated by motors.

Some Recent Inventions.

IMPROVEMENTS IN METHOD AND APPARATUS FOR HEAT-TREATING METAL SHEETS.

In the accompanying illustration Fig. 1 a transverse section of a furnace, cooler, and conveyor is shown, suitable for heat-treating sheets fed in lime. Many improvements are embodied in the design of this furnace and in the method of treating the metal sheets. It has been designed more particularly for continuously annealing and cooling metal sheets, and provides means for transporting the shee.s through the furnace and cooling chamber so that they are arranged vertically. This method enables the furnace to be designed so that the cross-section has the minimum area, which permits a high velocity of gas through the furnace, with an effective transmission of heat to the sheets, so that they can travel at an economical speed and be heated evenly without distortion, the furnace being sealed to maintain a high pressure. The conveyor for transporting the sheets is so arranged that the sheets are supported by their top edges, and in such a way that the main part of the conveyor is protected from the direct action of the gases. The roofs of the furnace, cooling chamber, and conveyor are designed and arranged to facilitate their removal for repair.

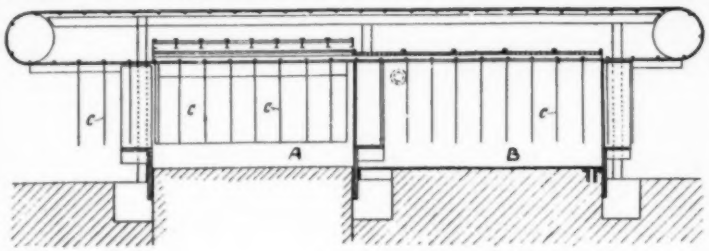


Fig. 1.

To avoid the necessity for employing the exhaust gases from the annealing furnace as the cooling medium in the cooling chamber, the gas fuel employed for this purpose is arranged to pass through the cooling chamber on its way to the furnace. The cooling chamber is so constructed that air is excluded, in order to prevent combustion of the fuel gas in the chamber; in this way the gas is preheated. The arrangement also permits the products of combustion to be passed through a recuperator, which is adapted for heating the combustion air for the furnace. The arrangement of this apparatus is suitable for all the ranges of size and thicknesses of sheets, and the minimum of adjustment is necessary when changing from sheets of one size or thickness to sheets of another size or thickness.

Transporting the sheets through the annealing furnace and subsequently through the cooling chamber is done in a very ingenious way. The sheets are passed through the furnace with their planes vertical, each sheet being supported from a conveyor by its top edge, and being carried forward whilst the main portion depends vertically into the furnace. Any suitable form of gripping devices on the conveyor may be employed to hold the top edge of the sheet; but if the latter require to emerge from the process without any marking, such as would result from the gripping of the upper edge, or where such gripping, due to contact with parts cooler than the sheet, would prevent the top edge from being raised to the desired temperature the size of the sheets fed to the furnace is so arranged that at any stage in the process after the sheet has been through the furnace, a thin strip is cut off that edge of the sheet which was uppermost as it passed through the furnace, thus bringing the sheet to the standard size required. The upper edge may, therefore, be gripped by grippers formed on the conveyor, or may be punched to provide holes to fit hooks on the conveyor, or (and this is the preferred arrangement) a narrow strip of the said edge may, preparatory to the sheets being fed to the furnace, be turned over by means of seaming rollers until it makes an acute angle with the plane of the sheet, the hook-shaped edge so formed being adapted to engage the corresponding laterally disposed hooked arms carried from the conveyor, the engaging edge, if necessary, being turned over and beaded.

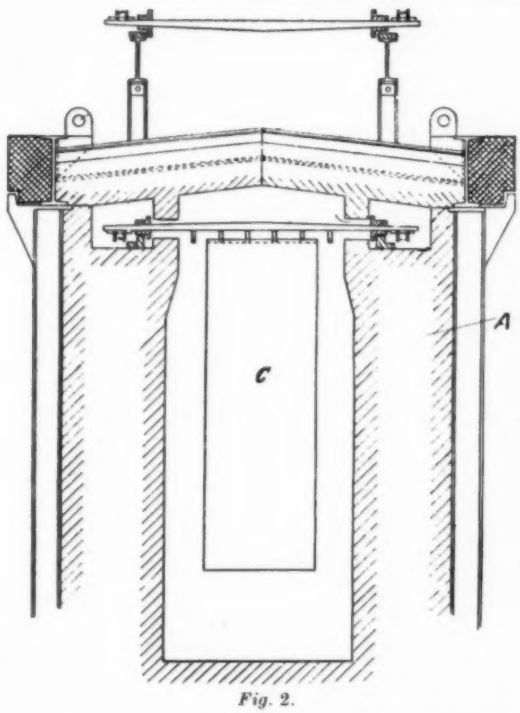


Fig. 2.

It has been found with exceptionally thin sheets of a comparatively large size, that if, in an acute angle as described, a reverse bend be given so that the configuration of the transverse section of the edge portion has a double fold, a more reliable attachment may be made to the hooked portion of the furnace conveyor arm, said hooked portion being such that the intermediate portion of the bent part of the sheet rests on a flat edge of the hooked portion of the arm, and is engaged by a safety catch or gripper carried by the conveyor arm, the outer turned-over portion being in rear of this gripper. With this arrangement, before a sheet can accidentally be released from the closed gripper, it is necessary that both folds of the sheet shall be pulled out by the weight of the sheet; with the section of bend described this is practically impossible.

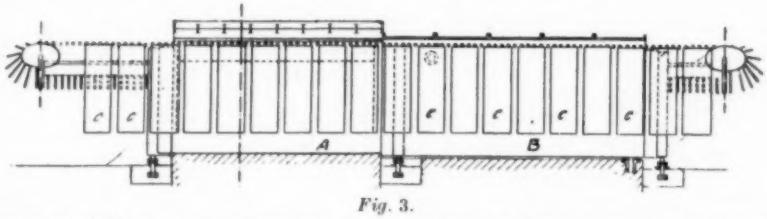


Fig. 3.

The suspension of the sheets by their top edges enables the sheets to be singly annealed whilst avoiding the difficulties experienced according to present practice, in which the sheets are carried on the conveyors with their planes horizontal, or with the sheets bent to convex shape: in such cases the sheets, when raised to annealing temperature, become soft, and unless they are supported at numerous

points the sagging due to their weight distorts them. When suspended by their upper edges, according to the present invention, whether moving in line or broadside on, the weight of the sheet tends to maintain each part of the sheet in the same vertical plane.

The sheets may be fed to and removed from the conveyor by automatic means or by hand. Where the edges are turned over, as described, the sheets may be fed to the conveyor over a series of obliquely disposed feeding discs arranged with their planes in line, or be arranged to hang from a similar series of magnetised feeding rollers ; either

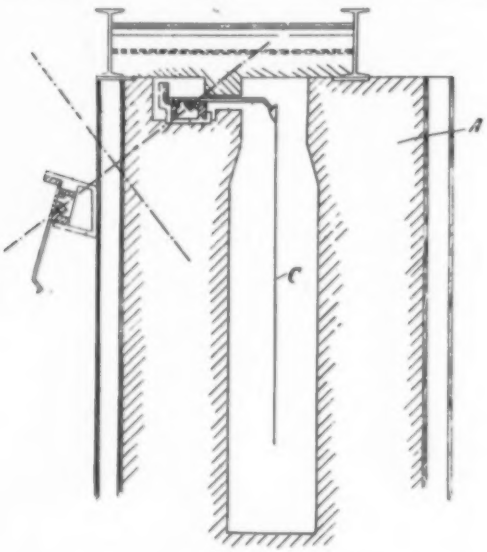


Fig. 4.

discs or rolls feeding the turned-over edge of the sheet into engagement with the conveyor hooks, by which the sheets are carried through the furnace and cooling chamber, entering and leaving the furnace and cooling chamber through sealing means, which close the ends of these chambers in comparatively air-tight manner ; after passing out of the furnace or cooling chamber, the sheet is delivered by the conveyor hooks on to a series of take-off discs or rolls, arranged in like manner to the feed discs or rolls.

In Fig. 1 the sheets are shown with their planes slightly inclined to the direction of motion, and the arrangement

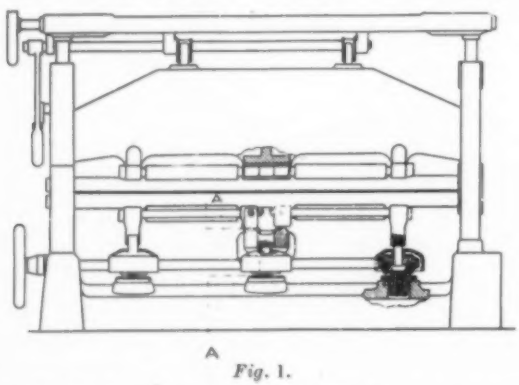


Fig. 1.

in longitudinal section is shown in Fig. 2—A representing the annealing furnace, B the cooling chamber, and C the suspended sheets.

Fig. 3 corresponds to Fig. 1, but the arrangement is modified to allow the sheets to pass through with their planes parallel to the direction of motion, while Fig. 4 indicates a longitudinal section of Fig. 3, showing the arrangement.

324,679. ERNEST GRIFFITHS and EVELYN E. GRIFFITHS, patentees. Messrs. SLOAN AND LLOYD BARNES, agents, 34, Castle Street, Liverpool.

AN ADJUSTABLE SUPPORTING MECHANISM FOR STRAIGHTENING ROLLS OF PLATE-STRAIGHTENING MACHINES.

THE straightening rolls of plate-straightening machines are invariably supported on supporting rolls, which are adjustably arranged so that they serve simultaneously for deflecting the straightening rolls towards the work. This enables the rolls to press particularly strongly along certain sections of the plate. If the work is hard, requiring heavy pressures for the straightening, the supporting rolls yield by deflecting at the middle, so that the straightening rolls often lack the necessary support at those points where they should exert the heaviest pressure. Under these circumstances the counter forces acting from the work to the rolls can influence the form of the straightening rolls' flexion curve in a manner which cannot be anticipated by the operator of the straightening machine. The form of the flexion curve cannot be regulated by hand in view of these counter forces, the strength and effect of which cannot be predetermined. These difficulties are claimed to be overcome by the use of an adjustable supporting mechanism.

According to this device the adjusting means arranged along the straightening rolls, designed to adjust the deflection, pass into their supporting position along paths of different lengths. This device is embodied in the accompanying illustrations, Figs. 1, 2, and 3 ; an elevation of a plate-straightening machine, with the adjustable supporting mechanism, being shown in Fig. 1 ; a section through the adjustable supporting mechanism on the line A—A being shown in Fig. 2, while Fig. 3 is a plan view of the middle part of this mechanism.

The upper and lower straightening rolls are journaled in the machine uprights. These rolls are each supported by two rows of supporting rolls, the upper supporting rolls being mounted in a yoke member, so that they participate in the adjustment movements of this yoke member, whereas the journals of the lower supporting rolls project into bearing bodies rigidly connected together in pairs by struts to form for each pair a bearing frame belonging to one row of supporting rolls. Two such rigid frames composed of a bearing body are, after the insertion of the corresponding row of supporting rollers, symmetrically arranged under the lower row of rolls, so that the inner

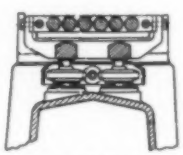


Fig. 2. *Section on A–A.*

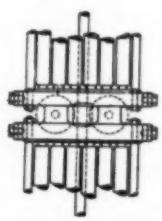


Fig. 3.

bearing bodies face each other and the outer bearing bodies are arranged away from each other. The inner bearing bodies are each supported in a hollow sliding surface of a middle part of the mechanism, so that they perform a slight oscillation—*i.e.*, slightly turn between the points of end screws around an axis at right-angles to the centre axles of the supporting rolls, for the purpose of inclined adjustment corresponding to the desired progress of the flexion curve of the straightening rolls. The middle part rests on two inner screw spindles, capable of rotation as adjusting means in nuts rigidly fixed on the lower machine frame.

By means of this supporting mechanism, it is possible, to a great extent, to positively adjust the shape of the deflecting curve of the straightening rolls, to obtain quickly the necessary stretching of the work, and thereby a good straightening result.

326,033. FRITZ UNGERER, patentee. FRANCIS H. ROGERS, agent, 181, Queen Victoria Street, London, E.C. 4.

Business Notes and News

Metallurgist Awarded Bonus.

Claiming that improvement in a gold-extraction plant devised by him had substantially increased the earnings of an African mining company, Mr. Herbert E. Arrowsmith, of Wembley, a metallurgist, was awarded a bonus of £1,400, in respect of his services, by Mr. Justice Macnaghten in the King's Bench Division recently. The claimant sued the London and Rhodesian Mining and Land Co., Ltd., of London, for money which he alleged was payable to him under an agreement. It was stated that the defendant company belonged to a group known as the Bailey group, and was interested in, or associated with, a number of mining undertakings in South Africa. Mr. Arrowsmith was formerly in the service of the company, and he caused certain alterations to be made in the plant of the Cam and Motor Gold Mining Co. (1919), Ltd., which resulted in a higher percentage of gold being extracted from the ore.

The defendant company denied that they were liable to pay bonus to Mr. Arrowsmith. Certain alleged plant improvements, they maintained, were adopted as the result of reports submitted by Mr. Arrowsmith when acting as a consulting metallurgist, before he entered their service, and those alleged improvements were not covered by the agreement sued upon.

Mr. Justice Macnaghten, giving judgment, said that it appeared that after contracting metal poisoning, Mr. Arrowsmith left the employment of the defendant company in 1928.

After studying statistics relating to the business of Cam and Motor Gold Mining Co. (1919), Ltd., the Judge came to the conclusion that, during the material period, that company, in consequence of the adoption of proposals made by Mr. Arrowsmith, got approximately £60,000, which would not otherwise have come to them. By the agreement Mr. Arrowsmith was entitled to a "small bonus" in respect of that result.

A New Application for Aluminium Alloys.

Progress of the light alloys for structural work has been demonstrated by the Aluminium Co., of Massena, New York, by building a 10-ton travelling crane, in the new structural mill, in which strong aluminium alloys have been used to a considerable extent. With the exception of the framework for lighter-than-air craft, this represents the largest structural application of aluminium alloys. The crane is a three-motor, single-hook machine, with a lift of 22 ft. The bridge is of aluminium alloy, and is fabricated from two double-web girders, spaced 7 ft. on centres. Aluminium is also used for the walkway, handrails, and operator's cage. The bridge girders frame into cast-steel carriages at their ends, and a one-piece cast-steel trolley, carrying the hoisting mechanism, is mounted on the girder rails. Although designed largely upon the usual practice followed in building steel cranes, the higher modulus of elasticity of the aluminium alloy necessitated girders somewhat deeper and wider and of greater sectional area than for steel construction. A standard steel crane of the same capacity and span length was erected for comparative purposes, the two cranes being similar in design, with the exception of the girders. A total saving in weight of 12 tons has been effected with the aluminium alloy crane. This saving in crane weight naturally effects a considerable saving on the supporting members throughout the whole length of the runway and in the power consumption.

THE Entrance Examinations for the award of British Empire Scholarships in the Faculty of Engineering, Loughborough College, have now been completed and awards made. The scholarships are tenable at Loughborough for the full period of the diploma course, and the Governors of the College have approved the following awards for 1930:—

1. Howell, J. C., Devonport High School.
2. Whitehead, J. R., Sutton Coldfield Grammar School.
3. Noble, N. E. D., Wellington College.
4. West, Fred, Swanwick Hall School.
5. Cox, Cyril C., Loughborough Junior College.

R. J. Gaul, of Plumtree, South Rhodesia, has been recommended for a present scholarship which will be vacant in September next.

These scholarships are open to all British subjects resident in any part of the Empire, and are of the value of £75 per annum.

Progress of Sydney Harbour Bridge.

It is hoped to connect the two great arches, which will form the span of the Sydney Harbour Bridge, this month. This bridge is being built for the New South Wales Government by Messrs. Dorman, Long and Co., Ltd. The bridge has a single span of 1,650 ft., and, when completed, is claimed to be the largest of its kind in the world. The contract was awarded to Messrs. Dorman, Long in February, 1924, at a contract price of £4,217,721, but owing to various circumstances the total cost of construction will probably exceed £6,000,000. One of the problems which the contractors had to meet was the construction of the huge structure without interfering with the large amount of shipping using Sydney Harbour.

In order to accomplish this the method of construction employed consisted of a single arch built out from each shore—Dawes' Point and Wilson's Point—simultaneously, each half being anchored back to the solid rock by a set of 128 steel-wire cables, each $2\frac{3}{4}$ in. in diameter. The tension of the cables increases with the length and weight of the arches, until it will reach in the next week or two no less than 27,000 tons. The critical stage in the erection operations will take place about the middle of this month when the anchorage cables, holding the extreme ends of each half arch about 3 ft. above their final position, will be gradually slackened to allow the arch to be joined. The construction of the arch requires 37,000 tons of steel, and the approach spans will absorb some 13,000 tons. When completed the bridge will represent one of the finest engineering feats in the world.

Canadian Railway's Scheme.

The Canadian National Railways propose to construct a new viaduct and railway terminus which will be about the same length as the Forth Bridge, and will embody many new principles in railway engineering. The scheme involves an outlay of about £10,000,000, and it is with a view to securing all or part of the contract that the British steel industry is directing its attention to the project. Should the contract be secured by British enterprise, the effect on the Clyde or the Tees would be very considerable, as it would keep steel-works going for many months, and help to create a more optimistic spirit in one of these districts. The scheme is in its early stages yet, and, although there are many difficulties in the way, it is hoped that the contract may be secured for British interests.

Steel Amalgamation Scheme.

A scheme for the amalgamation of the United Steel Companies, Ltd., and the United Strip and Bar Mills, Ltd., has been sanctioned. The scheme involves the vesting of the undertakings in a new company with a capital of £6,650,000, divided into 6,650,000 ordinary £1 shares, which will be issued to the holders of A debentures, B and C debenture stocks, unsecured obligations, and preference and ordinary shares of the Steel Company, and preference shares of the Strip Company, in lieu of their existing holdings.

The Steel Company was formed as a holding company to combine, in the Sheffield district, Messrs. Steel, Peech, and Tozer and Samuel Fox and Co., Ltd.; in the Lincolnshire district, the Frodingham Iron and Steel Co., Ltd., and Appleby Co., Ltd.; and in the Cumberland district, the Workington Iron and Steel Co., Ltd.; and also to acquire the control of the Rother Vale Collieries, Ltd., and other collieries supplying steel works.

Metallurgical History of Southern Africa.

Recent discoveries of the Italian Scientific Expedition in Northern Rhodesia seem to indicate that the iron age began long before the period generally associated with it. The expedition has reported the discovery of a site of what is claimed to be an ancient iron foundry. It has been discovered at a depth of six feet in a large cavern in strata of the palæolithic age, which has hitherto been regarded as the earlier stone age. The foundry was directly superimposed on a stratum in which Mousterian implements were discovered. An examination of skeletons discovered tends to show that an early knowledge of smelting came to Africa in Bushmen times, somewhere about the middle period of the palæolithic or earlier stone age. The discovery, which is an important contribution to archæology, should throw an entirely new light on the history of metallurgy, particularly in its relation to Southern Africa.

Reviews of Current Literature.

Pickling of Iron and Steel.

THERE is no doubt that pickling is now recognised as one of the most important aids to manufacturing, although, until recent years, this process as applied to iron and steel was one of the most neglected operations in the metal-working industries. Offensive fumes, corrosive action of acids, irregular results, and other discouraging conditions prevailed in many plants, and they are not yet entirely eliminated. Gradually, however, these conditions are being dispersed in the light of modern thought and progress. This is being achieved as a result of operating executives concentrating on the subject and bringing about improvements in equipment and consequently increase in efficiency.

Mr. W. G. Imhoff, the author of this work, was for five years Industrial Fellow, investigating pickling and galvanising at Mellon Institute of Industrial Research at the University of Pittsburgh, and much of the text is based on practical experience. Considerable information has been obtained as a result of interviewing and discussing the various problems arising in practice on the subject with practical men in various plants and occupying various positions. The book is comprehensive in its scope, covering black and white pickling, pickling for galvanising, tinning, and enamelling, and the design and operation of pickling departments. It has been prepared for the man in the plant rather than for the man in the laboratory, but there is no doubt it will have a wide appeal to both sections because of its essentially practical character, which facilitates application in practice.

The author obviously takes up the attitude that the smoothness of galvanised coatings is dependent upon the condition of the iron or steel base, and this condition is governed by the chemical composition of the pickling solution, the quality of the iron or steel, and the surface condition of the material after it has passed through its various finishing processes. Thus, it is profitable to consider facts about the base material, and fundamental facts of this character in regard to steel form the basis of the first chapter in this work. The methods of cleaning and pickling steel differ from those used for iron, and obviously the material to be given a protective metallic coating must be determined at the outset. The removal of impurities from a steel base is generally done by placing the material in a boiling solution of caustic soda, caustic potash, or a commercial cleaning compound. In some cases impurities must be burned off, while for enamelling the material is usually dipped in a solution of hydrochloric acid and subjected to a soft, yellow reducing flame in a furnace. The author emphasises the need of adequate cleaning as a preliminary to pickling, and details processes which experience has shown to give the best results.

Pickling is the process of removing scale, oxide, rust, and other foreign substances from the surface of metals by immersing them in acid solutions, and the acid solutions, their strength, the temperature at which they are used, and the time during which the base material is subjected to the pickling process, are all important factors. Production and tank capacity influence the pickling solution strength, but under standard conditions these are more or less constant. By varying the strength of a solution, the operation of pickling can be safely speeded up or slowed down within wide limits, to meet the demands of production. The author suggests that the better practice, however, is never to use more than 8 or 10% solution of sulphuric acid. Beyond this point, he claims that appreciable quantities of acid are lost, or time is wasted in completely exhausting the bath when it becomes too foul to be fit for longer use. For ordinary purposes a strength of 4 to 6% acid will pickle the average work in 30 to 40 mins., pickling time depending upon the temperature of the solution.

It is obvious that in a process containing so many important factors, proper results can only be obtained when the pickling conditions have been standardised, and one of the most important controlling factors is the temperature of the pickling bath. There are certainly difficulties in standardising the whole process, but standardising and controlling the pickling bath temperature is not only possible, but extremely practicable. The condition of acid brittleness in many steels that have been tested after pickling, emphasises the need for standardising pickling conditions. The author infers that in order to reduce pickling operations and practice to as scientific a basis as possible, modern methods and equipment should be used.

The book is not very large, but apparently quality of text has been aimed at rather than quantity. It is certainly full of information on the process of pickling that is definitely practical, and should prove of immense value to all concerned in the preliminary operations involved in coating iron and steel with protective metal coatings. It is well printed, adequately illustrated, and a very comprehensive bibliography, which is a revision of the one on the same subject, compiled in the technology department of the Carnegie Library at Pittsburgh, forms a final chapter.

By Wallace G. Imhoff. Published by the Penton Publishing Company, Cleveland, Ohio, U.S.A., and Caxton House, London, S.W. 1. Price, 25s. net.

Blacksmith's Manual Illustrated.

WHILE the increase in mechanical devices is evident in the smithy, as in other departments of a manufacturing concern, it has increased rather than reduced the degree of skill necessary in producing parts with the minimum of waste in effort, time, and material, consistent with modern progress. At one time the smith claimed to be the only craftsman capable of making his own tools required to produce a particular piece of work, and, although in part this is true to-day, the demand for speed in production, coupled with greater accuracy, has sectionalised the industry somewhat, and the training in blacksmith's work is not now so complete as formerly. It is not, of course, possible to train a smith by reading and studying a book, but his training can be supplemented by reading the experience of others and the methods they adopt to produce a finished job in the best, simplest, and quickest way. In a craft which involves considerable initiative it will be appreciated that a reference to what constitutes the best method in a particular instance may be a matter of opinion, and thus contentious, but it may provide a successful method from which a better method may emanate.

This work has been compiled by a practical man, and it contains solutions of difficulties encountered in his own experience and those of his fellow-craftsmen. The book demonstrates by simple text matter and an excellent use of illustrations, specimens of smith's work commonly done, and shows methods by which they can be accomplished. The author recognises the wide scope of forged work and the various methods by which different types may be done appear to be endless; consequently, many smiths are often at a loss in determining the commencement of a job and how to proceed with it. Unless the proper sequence of operations can be foreseen when beginning a job valuable time and material are likely to be lost. With a view to surmounting this difficulty, the author has illustrated a finished article and shown the sequence of operations in its production. The book includes information on forges; the various anvil, hand, and power hammer tools; estimation of lengths of material, and on hardening and tempering; in addition to a wide range of forgings for which a full production sequence is given in each case. The work is profusely illustrated, containing 755 perspective working diagrams, and should form a valuable aid to all interested in smith's work, and, in particular, to the apprentice smith who is desirous of facilitating the production of his work in an expeditious manner.

By J. W. Lillico. Published by Crosby Lockwood and Son, Stationers Hall Court, Ludgate Hill, London, E.C. Price 9s. net.

Some Contracts.

It is officially announced by the Great Western Railway that the following, among many contracts that have been placed, are included :—Two movable coal hoists and traverses at Queen Alexandra Dock, Cardiff, Hydraulic Engineering Co., Chester ; overhead contract line at Queen Alexandra Dock, Cardiff, Callender's Cable and Construction Co., London ; movable coal hoist and traversers at North Dock, Newport, Vickers Armstrong, Ltd., London ; steel-framed building at Preesgweene, Isaac Dixon and Co., Liverpool ; reconstruction of embankment road bridge and widening of adjacent bridge at Laira, Plymouth, Caffen and Co., London ; chain-grate stokers for Stirling boilers, Swindon, Edward Bennis and Co., Little Hulton, Bolton ; four electrically driven 50-ton and two 25-ton overhead travelling cranes for locomotive repair shop, Wolverhampton, Wharton Crane and Hoist Co., Reddish, Stockport ; construction of twin-screw tug, Charles Hill and Sons, Bristol ; 24 electric 3-ton luffing jib cranes for Newport, Cardiff, and Swansea, Stothert and Pitt, Ltd., Bath.

The London and North Eastern Railway Co. has placed contracts with G. A. Pillatt and Son, Nottingham, for alterations to the King's Cross locomotive depot, including the erection of new messrooms and other buildings ; with Caffin and Co., London, for the earthwork, retaining walls, culverts, drains, etc., in connection with the new inwards goods yard at Hull ; with Logan and Hemingway, Doncaster, for work in widening the main line between Skelton Bridge and Beningborough ; and with the British Power Railway Signal Co., London, for the conversion of pneumatic signalling to the electro-pneumatic system at Ashbury's Junction, Priory Junction, and Gorton Junction, Manchester.

The Central Argentine Railway have placed orders for axles with Steel, Peech, and Tozer Co., Sheffield, and for radial axles with the Yorkshire Engine Co., Sheffield.

The London Electric Railways have placed a contract with Cochrane and Co., Ltd., Ormesby Ironworks, Middlesbrough, one of the Furness group of companies, for 35,000 tons of cast-iron segments for the extension of the Piccadilly Tube railway from Finsbury Park to Cockfosters, which is to be 7½ miles in length.

John Brown and Co., Sheffield, have secured an order for 12,000 carriage and wagon axles for the Indian railways, and an order from Chile for 1,400 volute railway springs.

The Vulcan Foundry Co., Newton-le-Willows, has secured a contract for the supply to the North-Western Railway of India of 27 locomotives.

The Sudan Government Railways have placed an order with Kitson and Co., Leeds, for four heavy goods locomotives.

The Central Africa Railway have placed an order with the North British Locomotive Co., Ltd., Glasgow, for six locomotives and tenders.

Spencer (Melksham), Ltd., Melksham, Wilts., have received an order from the Great Western Railway Co. for a coal loading-out plant, with belt conveyers and hydraulic wagon tipplers, to be installed at Roath Dock, Cardiff, and from the London Power Co. for a coal-handling plant, with belt conveyers and Spencer-Elson wagon tipplers, for Willesden Power Station.

The Central Electricity Board have recently placed further contracts to the value of nearly £550,000 in connection with the electricity schemes which are now being carried out. These include :—Contracts for the supply of high-tension cables with British Insulated Cables, Prescot ; W. T. Glover and Co., Manchester ; Siemens Bros., and Co., London ; and Standard Telephones and Cables, London. Contracts for switchgear with the British Thomson-Houston Co., London ; Ferguson, Pailin, Ltd., Manchester ; the General Electric Co., Birmingham ; Metropolitan-Vickers Electrical Co., Manchester ; and A. Reyrolle and Co., Hebburn-on-Tyne. A contract for meters with Landis and Gyr, Ltd., London.

Vickers-Armstrongs, Ltd., have received an order from Lord Inchcape for a passenger ship for the Union Steamship Co. of New Zealand. The ship will be built at Barrow-in-Furness, and the main propelling turbo-electric unit will be supplied by the British Thomson-Houston Co. at Rugby in collaboration with Vickers-Armstrongs, Ltd.

The Portuguese Steamship Co. Carregadores Acoreanos, whose head office is in Ponta Delgada (Azores), has placed a contract with Swan, Hunter, and Wigham-Richardson, Newcastle, for the construction of a 3,500-ton 12-knot steamer, to be ready for service in January next.

R. and W. Hawthorn Leslie Co., Newcastle-on-Tyne, have received an order for a saddle-tank locomotive from the Admiralty.

The P. and O. Co. announces that orders for two steamers to be built for the company's Straits-China-Japan mail and passenger service have been placed with Alexander Stephen and Son, Ltd., Glasgow. These will be vessels of 14,500 tons gross measurement, length 520 ft., beam 70 ft., and 30 ft. maximum draft. They will be driven by single reduction geared turbines of 14,000 h.p., with steam from high-pressure water-tube boilers.

The Francois Cementation Co., Bentley, Doncaster, has secured a contract for part of the scheme of the Manchester Corporation for turning Haweswater lake into a reservoir. The work provides for the extension of the northern section of the Haweswater aqueduct and the construction of a conduit, five miles of tunnelling, and the laying of pipes. The amount of the contract is understood to be in the neighbourhood of £500,000.

The Vulcan Motor and Engineering Co., Crossens, Southport, have just secured a repeat order from the Hong-Kong and Shanghai Hotels, Ltd., for five Vulcan Duchess 26-seater omnibuses. The Vulcan Co. have also received an order from the War Office for 11 medium 3/5-ton subsidy-type chassis and cabs.

Meldrums, Ltd., Timperley, near Manchester, have recently received orders for 20 mechanical stokers for steelworks, electrical engineers, breweries, railways, machine-tool works, paper-mills, municipal baths, sawmills, dye works, hosiery works, lard manufacturers, and rubber manufacturers.

Owing to the failure of the Arapuni power plant, the Auckland (N.Z.) Power Board has decided to purchase additional generating machinery for a steam-power plant. The tender of a British firm for a 15,000-kilowatt alternator set at a cost of £27,325, has been accepted, but the purchase of two boilers has been deferred owing to the disparity between the British tender of £34,500 and a German tender of £20,000.

The Crown Agents for the Colonies have placed orders for a plate-bending machine with J. Bennie and Sons, Glasgow, and for a punching machine with Reynolds and Wilson, Ltd., London.

The Glenboig Union Fireclay Co., Glasgow, have received large orders for locomotive firebricks for the Central Argentine Railway, and for firebricks and fireclay for the Buenos Ayres Western Railway.

Dorman, Long and Co., Middlesbrough, have been awarded a contract by the Crown Agents for the Colonies for 836 tons of structural steelwork to be used on the new locomotive shops of the Ceylon Government Railways at Ratmalla. The first part of the order for these new workshops was placed with the Tees Side Bridge and Engineering Works, Ltd., Middlesbrough, who received the order for steelwork for the stores.

The Metropolitan Water Board have awarded contracts to E. D. Winn and Co., London, for work in connection with the remodelling of the Surbiton and Ditton pumping station, at a cost of £69,564 ; to W. H. Allen, Sons, and Co., Bedford, for a steam-driven centrifugal pumping engine for Kempton Park pumping station ; and to Ashworth and Parker, for two steam-driven electric generators, switchboard, and piping for Deptford pumping station.

Some Contracts—continued.

Subject to the approval of the Ministries of Health and Transport, Messrs. Dorman, Long, and Co., Middlesbrough, have secured the contract for the strengthening of Scotswood Bridge over the Tyne. The work will require 350 tons of steel, and the contract price is £30,343.

The Government of Assam have awarded the contract for the first year's programme for the construction of road bridges in Assam to Braithwaite and Co. (India), Ltd. The whole programme, spread over a period of three years, is estimated to cost £125,000.

The North Metropolitan Electric Supply Co. have placed an order for four pulverised-fuel boilers for their Brimsdown power station with International Combustion, Ltd., London. The same company have also placed an order with Andrew Barclay, Sons, and Co., Kilmarnock, for a fireless locomotive for use at Brimsdown.

The Steel Co. of Scotland, Ltd., Glasgow, has received an order from the Victorian Railways, Australia, for best steel boiler plates at the price of £11 8s. 9d. a ton.

The British Engineers' Association announce that the War Office has placed a contract with John I. Thornycroft and Co. for over 40 of their latest type of six-cylinder rigid six-wheeled motor-vehicles to supplement the large fleet of these they already have in service with the Army Mechanical Transport.

The Crown Agents for the Colonies have awarded a contract for mixed traffic tank locomotives, of the 2-6-2-type meter gauge with the Vulcan Foundry Co., Newton-le-Willows. These locomotives are for service on the Kenya and Uganda Railways.

Catalogues and Other Publications.

A very useful brochure has been published by McKechnie Brothers, Ltd., of Birmingham, which is full of information respecting their wide range of non-ferrous metals. It contains the compositions of standard non-ferrous metal ingots produced by this firm, together with physical properties and suggested applications. All interested in brass and bronze rods and sections, solid metal pressings, chill cast bars, anti-friction metals and non-ferrous metal alloys, should send for this brochure.

The July issue of *Welding News* contains an informative article on Production Welding, and the importance of welding design on the strength and durability of the welded object is considered in an article on the "Position of the Weld." *Welding News* is published quarterly by the Institution of Welding Engineers, 30, Red Lion Square, London, W.C. 1.

The July issue of the *Nickel Bulletin* contains a very informative article on Aluminium Alloy "Y," by S. L. Archbutt, F.I.C. It forms the first of a series of articles dealing with light aluminium alloys to be published in this monthly bulletin. Other articles, in addition to the usual features, make this a very useful issue. It will be forwarded to all interested on application to the Bureau of Information on Nickel, The Mond Nickel Co., Ltd., Imperial Chemical House, Millbank, London, S.W. 1.

We have received a copy of *The Resistances Furnace*, which deals with electric furnaces for casehardening special steels by nitrogen. It refers particularly to the manufacture and supply of a suitable electric furnace that has been developed for the *Nitrard* process, which is now available, in various types, for use by steel manufacturers making nitralloy steel under licence. This brochure can be obtained on application to Electric Resistance Furnace Co., Ltd., 17, Victoria Street, London, S.W. 1.

A useful catalogue of pneumatic tools and appliances has recently been issued by Holman Brothers, Ltd., Camborne, Cornwall. It refers to stationary and portable compressors, hoists, air motors, pump units, various types of haulages, mandrels, drifters, sinkers, etc., all of which are carefully tabulated in types giving all the essential particulars.

We have received a catalogue of the various testing machines and appliances manufactured by Alfred J. Amsler and Co. It has been issued to summarise briefly the firms manufactures in about 40 pages, but they will be pleased to place their services at the disposal of those interested in any particular type of machine or apparatus, and to provide fully detailed descriptions and quotations. The catalogue is available on application to the Sole Agents, T. C. Howden and Co., 5 and 7, Fleet Street, Birmingham.

We have received the third edition of the *Edgar Allen Steel Foundry Book*, which has been enlarged to 52 pages. It has been thoroughly redesigned, and includes many facts in regard to manufacture, heat-treatment, and properties of castings in seven different kinds of steel. The book is excellently prepared and illustrated, and the text is both interesting and informative, giving a full description of conditions in steel-foundry practice, a knowledge of which reduces errors likely to lead to unprofitable and unnecessary expense. It is issued by Edgar Allen and Co., Ltd., Imperial Steel Works, Sheffield, and all interested in the purchase of steel castings will find its perusal profitable.

Aluminium Alloys for Heat-Treated Castings.

(*Continued from page* 152.)

(of the type discussed here) is to improve considerably the tensile strength, elastic limit, elongation, hardness, resistance to impact, or resistance to alternating fatigue. Castings are treated with the view to enhancing any one or more of these properties. Aluminium alloys having low limits of proportionality as cast, are naturally unsuitable for sustaining high static stresses or high dynamic stresses (fatigue); by suitable heat-treatment, good elastic properties may be conferred on such alloys.

Uses of Heat-treated Castings.

The development of heat-treatment processes as applied to aluminium-alloy castings has opened up new fields of usefulness for cast parts, and made light alloy castings more adaptable and serviceable for standard applications. There have been many interesting developments of recent years which have made possible the use of heat-treated cast aluminium alloys in place of malleable iron and steel castings, brass and bronze castings, and even steel forgings. Heat-treatment has made possible the production of light alloy castings with so much higher mechanical properties that such castings are now used for a wide variety of engineering purposes where it was formerly impractical to consider aluminium alloys at all. Such castings have now been on the market long enough, and in service under such a variety of conditions as to thoroughly demonstrate their worth. Briefly, the field of application is for stressed parts of any kind (and generally in place of heavier alloys), the only limitation being the possible mechanical properties.

Among specific uses for heat-treated aluminium-alloy castings may be mentioned the following:—Crankcases (for aircraft, motor-car, motor-coach, truck, and fire engines), transmission cases, rear axle, and differential housings, cylinder heads, pistons for gasoline and Diesel engines, bearing caps, brake shoes, wheels, outboard-motor parts, engine-suspension brackets, and street-car parts. In aircraft, heat-treated castings are used for pump and fuel system parts, brackets, levers, wheels, cylinder blocks, crankcases, supercharger parts, and a variety of small castings. While, so far, the chief applications have been in the transport field (including aircraft, motor-cars, coaches, and trucks), interesting uses have also come in the moving parts of general machinery. There is an especially good future for the use of heat-treated castings in the construction of steam and electric railway cars.

At the present time, practically any type of casting, irrespective of size, shape, or weight, can be heat-treated, and the actual weight of parts treated has ranged from less than 1 oz. to over 1,000 lb. Heat-treatment plant is now a necessary adjunct in the modern aluminium-alloy foundry, and in the future the foundryman will be called on more and more to produce castings in special alloys, heat-treated, and to rigid specifications.

Tenth International Acetylene Congress.

THE special merits of the use of welded structures in place of iron castings and riveting were emphasised during the course of the Zurich Congress, notably by Professor C. F. Keel, of Basle. Professor Keel pointed out that the great advantage of high stability, which hitherto has been so generally emphasised in connection with the use of cast metal parts produced in large numbers, is to-day greatly reduced. Resistance to shock and vibration depends on the modulus of elasticity of the material used for the work, and not on the weight of the material alone. It can be shown that where machine parts are exposed to shock steel is a more satisfactory material to use than cast iron.

In regard to the general application of the oxyacetylene processes in the construction of steel framework for buildings, bridges, roofs, masts, etc., Professor Keel described in detail the various welding joints used in such work, his paper being illustrated with lantern slides which showed not only these various types of joints but several buildings which had been constructed in which welding played a prominent part.

As compared with riveting, autogenous welding offers great advantages in many cases : greater solidity, less time required for erection, reduction in weight, greater resistance to corrosion, simplification of control of stores of the necessary cylindrical sections, and the frequent possibility of using tubes instead of cylindrical sections.

Mr. R. Meslier submitted papers describing new methods of welding which have been the subject of experimental work within the last year or so at the research laboratories of the Central Office for Acetylene and Autogenous Welding in Paris. In the first paper Mr. Meslier emphasised the importance of protecting the weld metal in a state of fusion from coming into contact with noxious gases. In a further paper Mr. Meslier described a recently introduced method of welding known as "upward welding with a double seam," which, it is claimed, greatly minimises liability to perform welds upon fairly thick sections of metal without continuous penetration along the whole length of the weld. Very briefly, this welding technique amounts to the welding of two pieces of metal which are placed for the purpose in an upright position, and the welding is carried out from the bottom upwards, building up by layers, each deposited upon and fused with the one below as well as with the sides of the parent metal.

It is apparent from the British Report to the Congress which is reviewed in this issue, that electric welding has made greater headway in Great Britain than on the Continent, and this opinion is borne out by this year's Congress, as, out of 67 papers submitted, only about half a dozen deal with electric welding. Of these a short but very interesting paper was submitted by M. Bonami and M. Goelzer, on the construction of a travelling crane with a lift of 25 tons and a span of 20 metres, assembled entirely by means of electric-arc welding.

Considerable attention was paid to technical questions in connection with dissolved acetylene, the influence of temperature on dissolved acetylene cylinders. The training of welding operators was also given a deservedly important place in the proceedings, and M. Rosemberg presented to the Congress the result of a questionnaire widely distributed in Europe and America, designed to elicit information as to the methods adopted in many countries in regard to this important subject. This included the report of the British Acetylene Association, which is a very comprehensive work embracing the progress of oxy-acetylene welding and cutting throughout the British Empire.

The increasing demand for hack-saws has caused Messrs. Frys (London), Ltd., to redesign their hack-saw blade hardening shop. New furnaces on a conveyer system have just been installed, which will more than double their former output. The preliminary tests of blades from these furnaces have been very satisfactory.

Iron and Steel Foundry Practice

(*Continued from page* 136.)

content in some cases is as low as 0·25%, but, generally, if allowed to exceed 0·60% trouble is likely to arise as a result of cracking, as the castings are very hard and brittle. The heat-resisting alloys, if properly made, are tough, somewhat difficult to machine, and show excellent tensile strength from normal temperature up to about 900° C. There is a gradual reduction in strength, but it is not by any means as rapid as with other metals or alloys. The outstanding feature of these alloys is their remarkable resistance to oxidation, as they show little or no trace of scale after lengthy service. If care is taken in not overloading them, and in not heating or cooling them too rapidly, their life will be prolonged. These alloys are used for annealing pans, carburising boxes, lead pots, branding irons, oil burners, furnace parts, etc.

Molybdenum and Vanadium.

Of the more successful of the other elements used in producing alloy steels mention may be made of molybdenum and vanadium, which when used, are more commonly in combination with elements previously mentioned. Molybdenum steel is not in common use for castings, although it offers advantages in that there is less danger of cracking. Parts can be welded to this alloy with relative ease. In conjunction with chromium, however, the use of molybdenum is increasing rapidly. The outstanding effects of this element are the unusually high elastic ratio, high tensile strength, and good ductility it imparts to the steel. In comparison with nickel-chrome it is easier to machine. The molybdenum content is usually between 0·20 and 0·40%, and the chromium varies between 0·70 and 1·10%, with carbon ranging between 0·20 and 1·0% for the general run of work.

Value of Molybdenum.

The addition of molybdenum to a nickel-chrome steel results in a metal that retains all the good qualities of the nickel and the chrome, the ease of machining of the chrome-molybdenum steel, and, in addition, has the peculiar characteristic of hardening almost as hard by air quenching as if a liquid medium were used. It is useful in reducing distortion, internal strains, fire cracks, and the amount of metal left on steel castings for machining purposes can be appreciably reduced. This makes nickel-chrome molybdenum steel the ideal metal for cast die blocks. These are steadily displacing forgings, due to the heavy expense of sinking the die into a solid block. They can also be re-sunk very cheaply, as they can be re-machined without annealing. With low carbon, at or nearly 0·30%, and higher nickel and chrome, a steel of very high ductility and elastic limit is obtained. It is highly recommended for high-pressure fittings, and wherever great strength is necessary.

Straight vanadium steels are rarely made. This element is more often used in conjunction with chromium. Vanadium is a strong deoxidiser, and no doubt this property contributes considerably to its value. An important characteristic imparted to steel by vanadium is the increased resistance to failure when subjected to repeated stresses. Castings in chrome-vanadium have been made for some time but are not in general use. They contain an amount of chromium varying between 0·70 and 1·4%, and from 0·14 to 0·25% vanadium.

A casting, as produced, in addition to being in a strained condition, is brittle and lacking in toughness, and in order to get the best results from the steel some form of heat-treatment is essential. Refinement in grain is obtained by heating the steel to what is known as the upper critical range, and, to obtain success, consideration must be given to the temperature, the rate of heating, time of soaking, and the rate and manner of cooling.

MARKET PRICES

ALUMINIUM.

99% Purity	£95	0	0
Castings, 2.L5 Alloy	lb.	1/3–1/8	
„ 2.L8 „	„	1/4–1/9	
„ Silicon „	„	—	

ANTIMONY.

English	£38	0	0
Chinese	26	0	0
Crude	20	0	0

BRASS.

Solid Drawn Tubes	lb.	10½d.
Brazed Tubes	lb.	12½d.
Rods Drawn	„	10½d.
Wire	„	9½d.
*Extruded Brass Bars	„	5½d.

COPPER.

Standard Cash	£48	7	6
Electrolytic	51	5	0
Best Selected	51	5	0
Tough	50	15	0
Sheets	79	0	0
Wire Bars	52	2	6
Ingot Bars	52	2	6
Solid Drawn Tubes	lb.	11½d.	
Brazed Tubes	„	11½d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	£0	2	8½
‡Ferro Tungsten	„	0	2	5½
§Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
2-4% Carbon, scale 11/- per unit	ton	30	15	0
4-6% Carbon, scale 7/- per unit	„	23	7	6
6-8% Carbon, scale 7/- per unit	„	22	12	6
8-10% Carbon, scale 7/- per unit	„	22	0	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 10/- per unit	„	33	12	6
§Guar. max. 1% Carbon, scale 13/6 per unit	„	38	2	6
§Guar. max. 0.7% Carbon, scale 15/- per unit	„	39	15	0
‡Manganese Metal 96-98% Mn.	lb.	0	1	3
‡Metallic Chromium	„	0	2	7
§Ferro-Vanadium 25-50%	„	0	12	9
§Spiegel, 18-20%	ton	7	5	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	5	17	6
20/30% basis 25%, scale 3/- per unit	„	7	17	6
45/50% basis 45%, scale 5/- per unit	„	11	10	0
70/80% basis 75%, scale 6/- per unit	„	18	0	0
90/95% basis 90%, scale 10/- per unit	„	25	6	0
§Silico Manganese 65/75% Mn., basis 65% Mn.	„	14	0	0
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	6
§Ferro Phosphorus, 20-25%	ton	16	0	0

FUELS.

Foundry Coke—						
S. Wales Export	£1	5	0	to £1	17	0
Sheffield „	0	17	0	„ 0	18	6
Durham	0	14	6	to 0	15	0
Furnace Coke—						
Sheffield Export	£0	17	0	to £0	18	6
S. Wales „	0	17	6	to 1	1	0
Blast-Furnace Coke, at ovens		0	15	6		

GUN METAL.

Commercial Ingots	£71	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	1	0
*Cored Bars	„	0	1	2

LEAD.

Soft Foreign	£18	5	0
English	19	15	0

MANUFACTURED IRON.

Scotland—			
Crown Bars	£10	5	0
N.E. Coast—			
Rivets	11	10	0
Best Bars	11	5	0
Common Bars	10	15	0
Lancashire—			
Crown Bars	10	5	0
Hoops	13	0	0
Midlands—			
Crown Bars	10	7	6
Marked Bars	12	10	0
Unmarked Bars		—	
Nut and Bolt Bars	9	2	6
Gas Strip	11	2	6
S. Yorks.—			
Best Bars	11	10	0
Hoops	12	0	0

PHOSPHOR BRONZE.

*Bars, Tank brand, 1 in. dia. and upwards	lb.	1/–
*Cored Bars	„	1/2
†Strip	„	1/0½
†Sheet to 10 W.G.	„	1/1½
†Wire	„	1/1½
†Rods	„	1/1
†Tubes	„	1/6
†Castings	„	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	19	6
Foundry No. 1	3	19	0
„ No. 3	3	18	6
N.E. Coast—			
Hematite No. 1	3	11	6
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Cleveland—			
Foundry No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	15	0
Forge No. 4	3	6	0
N.W. Coast—			
Hematite	4	8	6
Midlands—			
N. Staffs Forge No. 4	3	11	0
„ Foundry No. 3	3	16	0
Northants—			
Forge No. 4	3	7	6
Foundry No. 3	3	12	6
Derbyshire Forge	3	11	0
„ Foundry No. 3	3	16	0
West Coast Hematite	4	7	6
East „ „	4	3	6

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron	£6	0	0	to £7	10	0
Bars, hammered, basis	£17	10	0	„ £18	10	0
Blooms	£10	0	0	„ £12	0	0
Keg steel	£32	0	0	„ £33	0	0
Faggot steel	£20	0	0	„ £24	0	0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£44	0	0
„ Braziery	41	0	0
„ Wire		—	
Brass	32	10	0
Gun Metal	43	0	0
Zinc	9	10	0
Aluminium Cuttings	56	0	0
Lead	12	15	0
Heavy Steel—			
S. Wales	2	16	0
Scotland	2	10	0
Cleveland	2	8	0
Cast Iron—			
Lancashire	2	12	6
S. Wales	2	15	0
Cleveland £2 15 0 to	2	17	6
Steel Turnings—			
Cleveland	2	2	6
Lancashire	1	7	0
Cast Iron Borings—			
Cleveland	1	19	0
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£13	0	0
English	16	17	6
India	14	15	0
Re-melted	14	15	0

STEEL.

Ship, Bridge, and Tank Plates—			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	10	0	0
„ „ (Marine) „	10	10	0
„ „ (Land), N.E. Coast	10	0	0
„ „ (Marine) „	10	10	0
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	10	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails	8	17	6
Sheffield—			
Siemens Acid Billets	9	10	0
Hard Basic	9	12	6
Medium Basic	8	2	6
Soft Basic	6	10	0
Hoops	9	15	0
Manchester—			
Hoops	9	15	0
Scotland, Sheets 20 W.G.	9	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 18% Tungsten	lb.	3/–
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to $\frac{5}{16}$ in.	„	1/–
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	3d.

TIN.

Standard Cash	£134	7	6
English	135	0	0
Australian	136	5	0
Eastern	138	5	0
Tin Plates I.C. 20 × 14	box	18/3	
Block Tin Cash	£134	7	6

ZINC.

English Sheets	£26	0	0
Rods	30	0	0
Battery Plates	23	10	0

* McKechnie Brothers, Ltd., quoted Aug. 6. † C. Clifford & Son, Ltd., quoted Aug. 6. ‡ Murex Limited, quoted Aug. 6.

Pearson & Knowles' Current Basis Prices:—Wrought Iron Bars, £10 5s. 0d.; Mild Steel Bars, £7 17s. 6d.; Wrought Iron Hoops, £12; Best Special Steel Baling Hoops, £9 15s. 0d.; Soft Steel Hoops (Coopers' and Ordinary Qualities), £9; C.R. & C.A. Steel Hoops, £12 10s. 0d. to £13 10s. 0d. All Nett Cash. Quoted Aug. 6.

§ Prices quoted Aug. 6, ex warehouse.